Light and Lighting

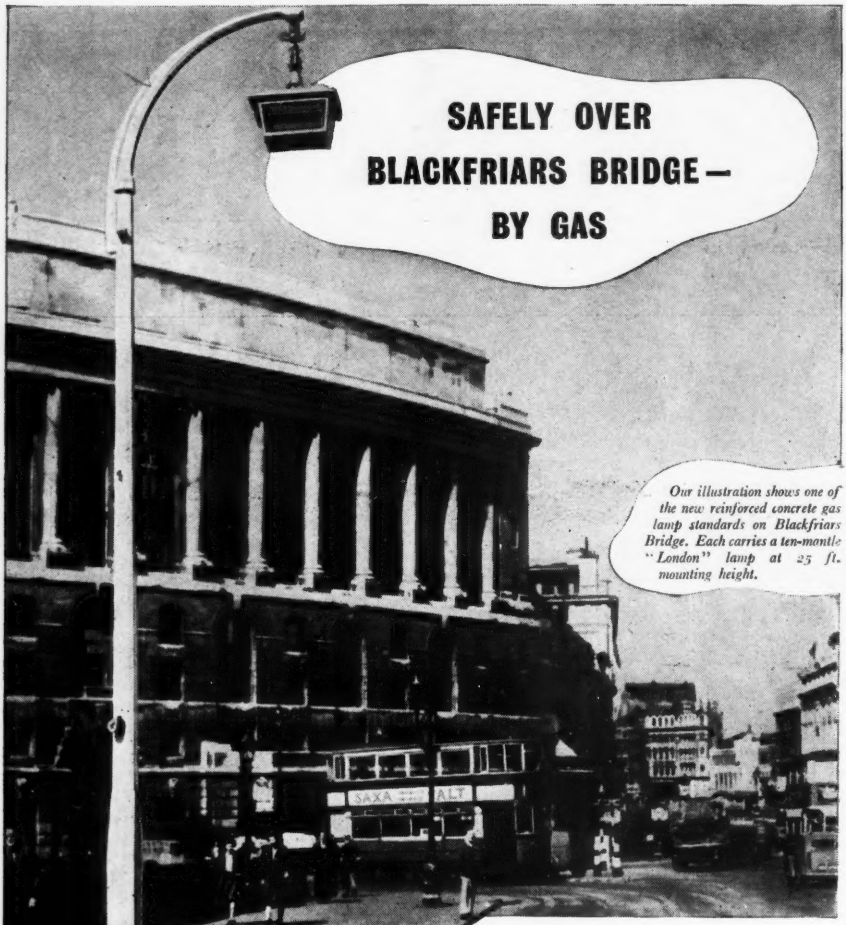
Vol. XLII.—No. 11 November, 1949 Price - One Shilling

Newly redecorated, but structurally unaltered, the Architectural Lighting Studio at the Lighting Service Bureau in London offers the visitor an exciting combination of light and colour. This room is just one of several, demonstrating lighting principles and applications which are open to all those interested in electric illumination.

The Aim

The aim of the Lighting Service Bureaux is to promote the full and proper use of light in the service of the community.

The Lighting Service Bureau of the Electric Lamp Manufacturers' Association, 2, Savoy Hill, London, W.C.2.



Gas and gas equipment pave the way for better street lighting. In its flexibility, gas provides that essential contrast between background and object on the roads at night. In its economy, gas allows lighting engineers to plan installations giving the best possible results at the lowest cost. In its reliability, gas ensures that an efficient lighting system will stay efficient for a long time, with a minimum of maintenance. The application of gas to street lighting, with practical examples, is covered in "Light on the Roads"; may we send you a copy of this informative booklet?

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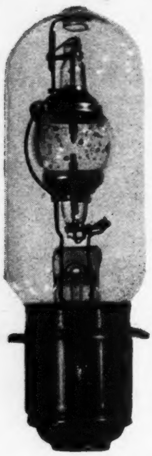
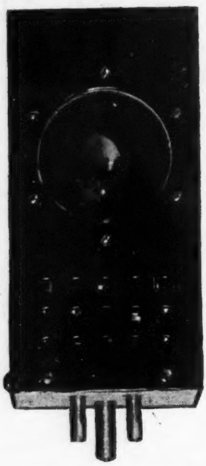
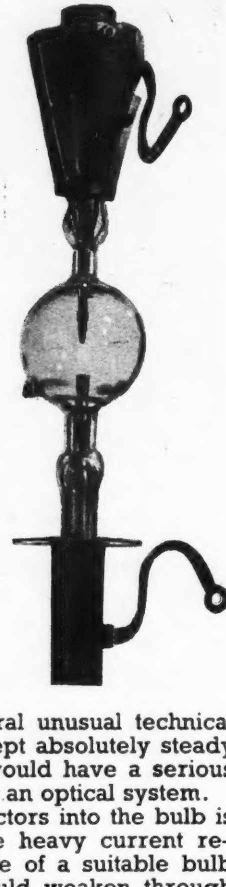
Lighting Development and Research







Three compact source mercury lamps, type ME. LEFT : 500 watt. CENTRE : 250 watt, in metal box with window. RIGHT : 2500 watt. In these lamps the source of light is a very short intensely bright arc between solid tungsten electrodes contained in a spherical quartz bulb which requires no artificial cooling.

Compact Sources

The manufacture of these lamps presents several unusual technical problems. In the first place the arc must be kept absolutely steady between electrodes, for any slight movement would have a serious effect on the steadiness of the beam projected by an optical system. Secondly, a new technique of sealing the conductors into the bulb is necessary, since normal seals cannot carry the heavy current required : and a third difficulty lies in the choice of a suitable bulb diameter and thickness. Too small a bulb would weaken through over-heating and burst under the vapour pressure developed, and too large a bulb would be mechanically weak in relation to the internal pressure even though it remained relatively cool.

Through research in the laboratories of E.L.M.A. members these problems were solved, and today the lamps are available for projection purposes. This is yet another step forward in the ceaseless progress of the British electric lamp industry.

The Lighting Service Bureau of the Electric Lamp Manufacturers' Association, 2, Savoy Hill, London, W.C.2.

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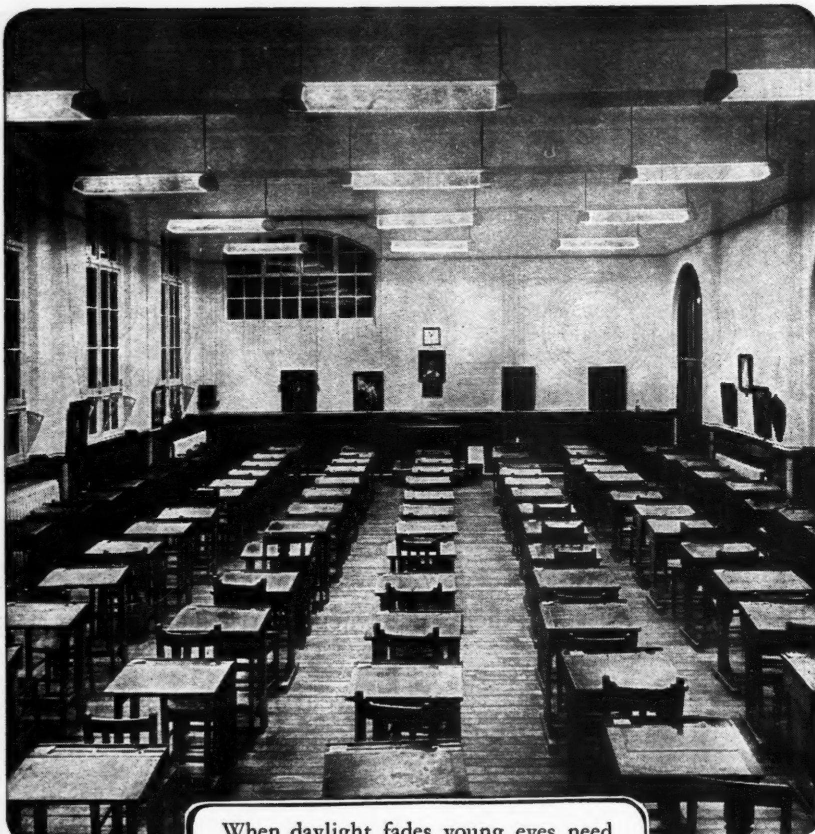

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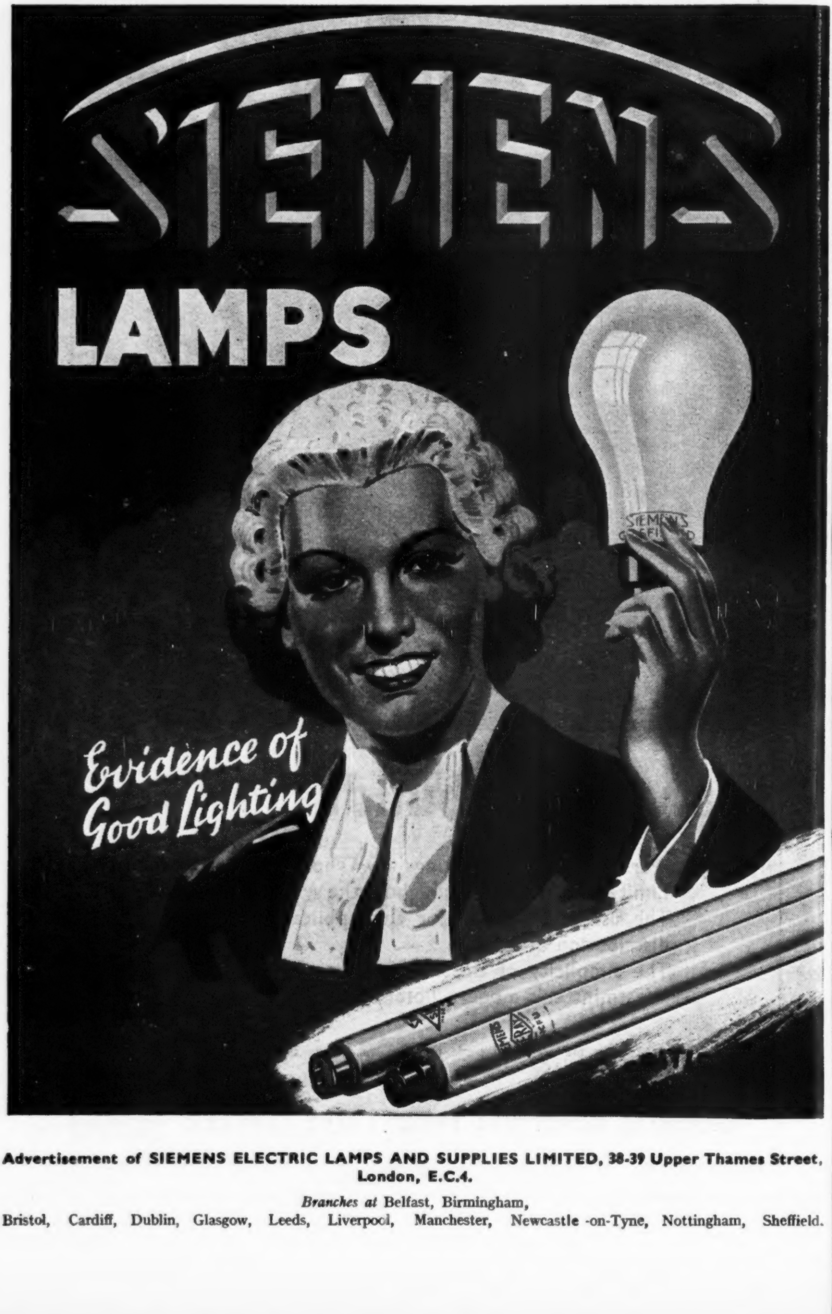

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CONTENTS

Hospital Lighting

PERHAPS nowhere is it more important that there should be suitable lighting than in hospitals. It is not enough, as the authors of a recent paper on this subject put it, that there should be no conditions of lighting which are harmful to patients. Hospital lighting should assist doctors and nursing staff in their care and treatment of the sick, not only directly by its revealing power, but also by its effect upon the patients, for " light is grateful and cheering to the spirits." Design both for daylighting and artificial lighting should be the best, though, in fact, it is singularly poor in some hospitals. Especially important are the provisions made for artificial lighting, for if time waits for no man neither do the disorders and accidents of man wait for time; night and day they come, endure and are treated. By day as well as night, artificial lighting is required for the delicate and critical work of the surgeon and, since colour is significant for diagnosis, there appears to be a good case for adopting a standard illuminant.

Illumination Notes and News

Fluorescent Lamps

Many readers will by now have seen, or had their attention directed to, an article in the October issue of the "Reader's Digest' describing the alleged dangers of broken fluorescent lamps. The first paragraph of the article includes the rather sweeping statement that "because fluorescent tubes contain a highly poisonous substance, serious injury may strike anyone who carelessly mishandles a broken tube."

The "Reader's Digest" appears to be made up of articles which originate in the U.S.A. Statements such as the one quoted above may be all very well if written for and read by an American public only. But apparently this magazine is published in 11 editions, apart from the American version, and circulated in many countries where such statements might lead to serious misconceptions. If readers of the article appreciate that the remarks refer only to American practice, all very well and good; but even in this matter we are bound to express the opinion that the account is misleading in the extreme. Unless interpreted correctly the article is, therefore, liable to be harmful to the electric lamp industry.

Some months ago, when a similar scare was raised in this country, British manufacturers stated in the technical Press that they did not now use beryllium compounds in fluorescent lamps. The actual material referred to is, as our readers well know, zinc beryllium silicate, and we are advised that it is a mis-statement to describe this compound as a highly poisonous substance.

Our readers are reminded that very many chemical compounds used in large quantities in various industries and in the arts may exercise on a minute percentage of the populace, allergic to them, some irritant effect if the substance is rubbed into a cut or wound.

Hundreds of millions of fluorescent lamps have been used in America in the past ten years, and the number of injuries ascribed to their mishandling is negligibly small. In any case we understand that leading American lampmakers have now adopted the halo-phosphate powders developed in this country.

As the author of the article in the "Reader's Digest" does not appear to be satisfied that these halo-phosphate powders are above suspicion, we are happy to be able to take this opportunity of reassuring him on the point.

While handling broken tubes obviously calls for reasonable care to avoid cuts, our readers need have no fear of any other ill-effects.

Next I.E.S. Sessional Meeting in London

The next I.E.S. Sessional meeting in London will be held at the Lighting Service Bureau, 2, Savoy-hill, W.C.2. at 6 p.m., on Tuesday, December 13.

The paper to be presented will be on "The Operation and Maintenance of Fluorescent Lamp Installations" by W. A. R. Stoyle and G. D. Jones-Thomas. The paper discusses the problems of the maintenance engineer in connection with fluorescent lamps and deals in a practical way with those lamp and circuit characteristics which have particular application to the question of maintenance. Testing methods and the detection, identification and correction of faults are dealt with.

The I.E.S. Register

There still appears to be a misconception regarding the relationship between the I.E.S. Fellowship and Registration schemes. We have, on behalf of the I.E.S., stated in the past that these schemes are not different grades of the same thing; and only recently the I.E.S. took steps to raise the standard of Fellowship so as to emphasise the difference between it and registration. Fellowship is a distinction; admission to the Register is a qualification. It does not follow that a member who has achieved Fellowship of the Society is necessarily qualified as a lighting engineer; there are in fact a number of very distinguished Fellows, specialists in their respective fields as physicists, ophthalmologists, etc., who would not consider themselves qualified to design a lighting installation. Fellows of the Society who *are* qualified to design installations should therefore make application for inclusion on the Register in the normal way.

Incidentally, after February 1 next year, all applicants for the Register will be required to hold the City and Guilds Intermediate Certificate in illuminating engineering.

Our attention has been drawn to a comment we made last month on the City and Guilds examinations. Our remarks, taken out of the context, might perhaps have been taken to imply that the Inter. Certificate is the only requirement for qualification as a Registered Lighting Engineer. What we were trying to stress was that at some date in the future applicants for the Register may be required to pass the *Final* grade examination instead of the easier Intermediate grade examination. We are sorry if the wrong impression was given.

The I.E.S. Code

The latest edition of the I.E.S. Code which was issued early in the autumn has been well received by the technical Press. The most useful review coupled with some sound constructive criticism comes from the "Architects' Journal" for October 20. In the opinion of the reviewer the code deals far too briefly with glare in daylighting, but he agrees with others that the coloured illumination charts are very good.

It is stated that architects could do themselves and lighting much good by insisting on their lighting contractors conforming to the strictest letter of the code. We agree that if this could be done much bad lighting would be avoided.

The review concludes with what amounts to a challenge from the architectural profession to the lighting profession with the statement that "The I.E.S. have as hard a job to do raising their members' standards as they have in discovering what lies beyond engineering." It is apparent from this that at least one architect is familiar with the I.E.S. Transactions and with at least one presidential address; also that he feels that the standards set by the I.E.S. on the question of illumination levels are somewhat on the low side. The I.E.S. is always willing to consider new evidence which may call for a revision of their recommendations, and if the architects have any such evidence to offer no doubt the I.E.S. Code Committee would be glad to know of it.

1951 Joint Engineering Conference

To coincide with the Festival of Britain in 1951, we understand that an Engineering Conference will be organised by the Councils of the Institutions of Civil, Mechanical and Electrical Engineers. The conference will be held from June 4 to 15, and we hope that illuminating engineering will be among the subjects covered by the conference.

Floodlighting In London Parks

It is interesting to note that, subject to the approval of the Ministry of Fuel and Power, the London County Council hope to resume floodlighting at Kennington Park and Archbishop Park early next month and at Highbury Fields and Wapping Recreation Ground in time for Christmas.

Oxidised Aluminium in the Construction of Lighting Fittings

By V. S. HENLEY, B.Sc., F.R.I.C.

With the impetus derived from the recent relaxation in the lighting regulations it is an opportune moment to consider the advantages of oxidised aluminium and its alloys for the construction of lighting reflectors and ancillary fittings. Two main classes of oxidising process are available, namely the electrolytic or anodising process and the chemical immersion method. Aluminium reflecting surfaces are usually anodised, and Table I of reflection factors for " white " light collected from various sources indicates the results obtainable compared with other well-known reflecting materials.

It will be seen from Table I that the reflection factors of anodised aluminium compare favourably with other orthodox materials, but it is also evident that some form of brightening pretreatment, either chemical, such as " Alpol," or electro-chemical, such as " Alzak," is needed in order to secure the highest reflection factors. Aluminium lends itself to the production of both specular and diffusing finishes; for the former type aluminium of high purity is specially rolled to minimise surface defects, whilst the matt finishes are produced on aluminium of commercial quality or on sand-blasted aluminium of higher purity.

Influences of Anodic Coat Thickness

The reflection factor is also affected by the thickness of the anodic coating which for interior mild conditions should be not less than 0.0003 in. in thickness, whilst for outdoor or most industrial atmospheres a thickness of at least

Fig. 1. Alumilite anodised fluorescent fittings in Thos. Wallis' Oxford Street store.

Table I.
Total Reflection Factors for "White" Light.

Material	Total Reflection Factor
Commercial Aluminium	
Mill finish	53
Polished	73
Etched	75
Polished and anodised ...	65
Polished "Alpol" bright dipped and anodised ...	77.8
99.99 per cent. Aluminium	
Polished "Alzak" electro-polished and anodised ...	87
Polished "Alpol" bright dipped and anodised ...	82.2
Other Materials	
Chromium plate	62–66
Nickel plate	60–63
Stainless steel	60–65
Rhodium	70–78
Vitreous enamel (white) ...	75–80
Silvered glass	90–93

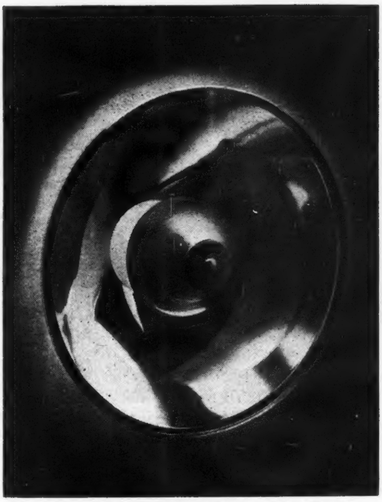


Fig. 2. Alzak processed aircraft landing light reflector.

0.0006 in. is desirable. Table II demonstrates the influence of anodic coat thickness on the reflection characteristics. The specimens were prepared by polishing, electro-brightening and then anodising.

Corrosion Resistance

Anodised aluminium reflectors have been in service for over 17 years in various parts of the world, and a number of weathering tests have been undertaken during that time. The conclusion derived from a survey of the available published reports indicates that any deterioration of an anodised reflector is mainly due to the following factors:—

(a) The presence of condensed moisture or rain.

(b) Water soluble corrosion agents, such as sulphur dioxide and salt.

(c) The deposition of solids on the reflector surface.

For obvious reasons, visored reflectors are least susceptible to any of these factors, whilst open reflectors on the coast or in heavy industrial areas are prone to a pitting type of corrosion that reduces the efficiency of the reflector.

In dry atmospheres a high content of sulphur dioxide can be tolerated, whilst

Table 2.
Influence of Anodic Coat Thickness on Reflection Characteristics.

Material	Anodic Coat Thickness	Specular Reflection Factor	Diffused Reflection Factor
	(Inches)	(Per cent.)	(Per cent.)
99.99 per cent. Al.	0.0001	83	0.3
	0.0008	80	0.4
99.8 per cent. Al.	0.0001	76	1.3
(Grade "E")	0.0008	63	2.3

Fig. 3. 5 kw. incandescent studio unit with Alzak reflector.

in a railway tunnel, for example, the corrosion of a thin anodic coating may commence within two to three weeks. Much attention has therefore been devoted to methods of improving the chemical resistance of anodic coatings, and a number of special "sealing" processes have been devised to reduce the solubility of the anodic coating in weak acids and alkalies. The corrosion resistance is also dependent on the thickness of the anodic coating to which due attention should be paid when specifying finishing requirements.

Maintenance

In view of the great importance attached to the effect of deposits of solids in accelerating the rate of corrosion the subject of maintenance has received careful consideration. It is essential to remove solid deposits at such intervals as are necessitated by local conditions and, as a guide, the wiping of reflector surfaces should be carried out either

(a) Annually; or

(b) When lamp replacements are made; or

(c) When the reflection factor has fallen to 75 per cent. of its original figure.

The cleaning of anodised reflectors should be effected with water and a soft rag, and if solids are difficult to remove a little abrasive cleaner should be employed *with water*. The application of a wax polish solution after washing is beneficial in reducing chemical attack by atmospheric deposits.

Chemical Oxide Coatings

Where a paint receptive corrosion resistant surface is required at an economical rate the use of a chemical oxidation process such as "Alrok" is indicated. These processes do not involve the use of electric current and can be applied to bezels, cast housings, brackets, and other items which will eventually be painted.

The use of oxidised aluminium in the lighting field continues to expand, and designers of fittings are recommended to approach their aluminium suppliers and a competent firm of anodisers when contemplating new fittings, in order to secure the most effective combination of grade of aluminium and method of finishing to suit the service conditions that are envisaged.

Acknowledgments

Acknowledgment is due to United Anodising, Ltd., for permission to publish this article, and to Alumilite and Alzak, Ltd., for providing the illustrations. Fig. 1 is published by permission of Debenhams, Ltd., and Hume Atkins and Co., Ltd.; Fig. 2 by permission of

(Continued on p. 307)

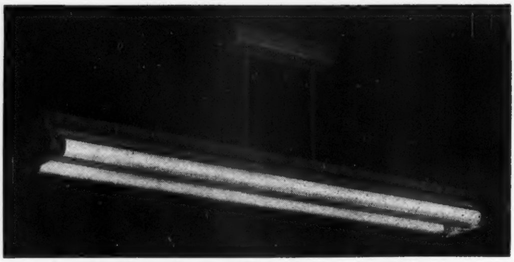
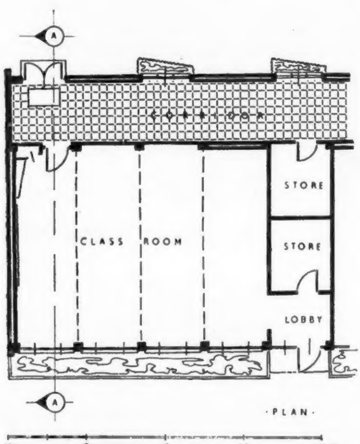


Fig. 4. Alumilite anodised fluorescent fitting.

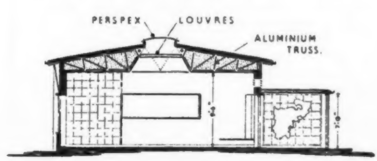
Natural and Artificial Lighting in a Classroom

Description of a prototype classroom designed by C. G. Stillman, Middlesex County Architect.



A new type of classroom of considerable interest to architects and educational authorities has been erected at the Lascelles School, South Harrow, by the Middlesex County Council. The classroom was designed by the county architect, Mr. C. G. Stillman, F.R.I.B.A. It is interesting mainly on account of the unusual daylighting features, the side windows being little more than a means of providing a view outside

Fig. 1. Plan and section of classroom.



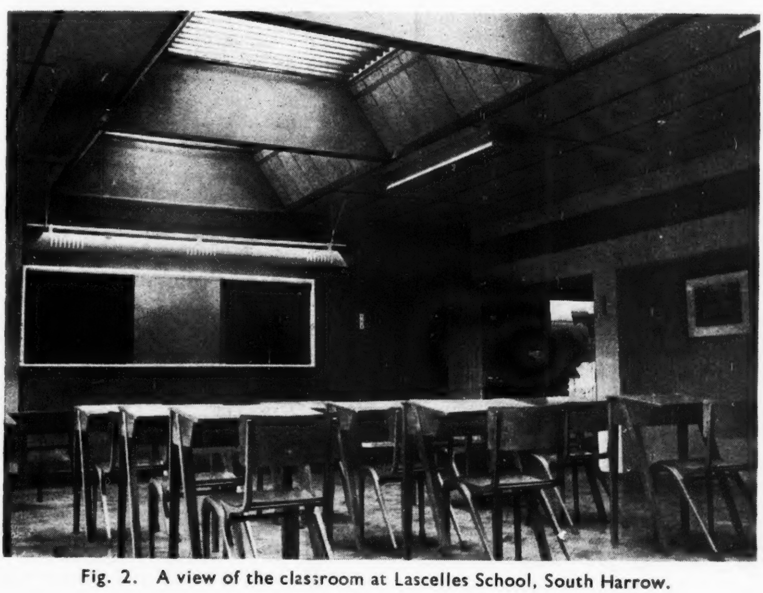
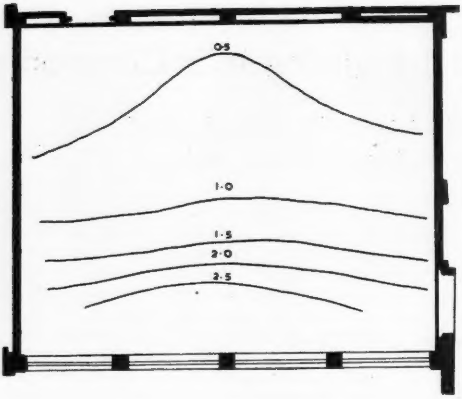


Fig. 2. A view of the classroom at Lascelles School, South Harrow.



the room, the main lighting coming from a large roof-light which gives a more even distribution of natural lighting within the room.

The room is 32 ft. long by 24 ft. wide, the height to the normal ceiling being only 9 ft. 6 in. As will be seen from Fig. 1, above the normal ceiling is a raised roof-light which runs the whole length of the room. This roof-light is made of corrugated "Perspex." In order that the amount of direct light, and hence glare, admitted to the room may be controlled, a system of adjustable louvres is fitted beneath the roof-light. These louvres can be adjusted by the teacher to any position between fully open or fully closed. There are also four windows

Fig. 3. *(Above)* Daylight factor diagram, side lighting only.

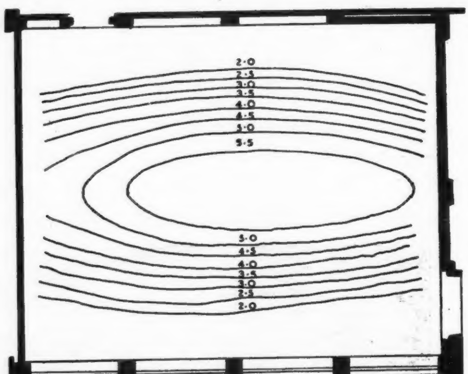
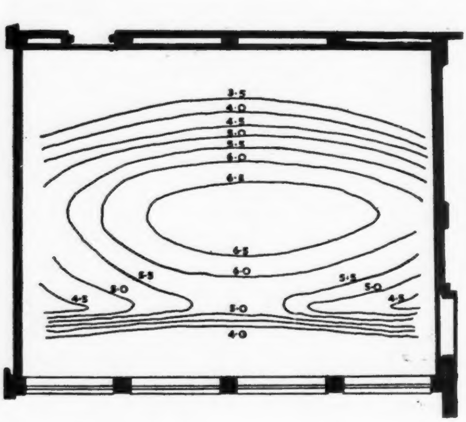


Fig. 4. *(Right)* Top lighting only.

Fig. 5. *(Below)* Daylight factors with side and top lighting combined.



on the side wall, but these are comparatively small, the intention being to minimise any direct view of the sky from within the classroom whilst at the same time permitting both outward vision and ventilation.

The walls and ceiling of the room are finished in light colours with the exception of the chalkboard wall which is a dull red, the chalkboard itself being dark green to give a suitable contrast and to help focus attention. Acoustic tiles on the left of the chalkboard, and only just showing in Fig. 2 are a bright blue.

Daylighting

Figs. 3, 4, and 5 show the daylight factor contours which were obtained for side lighting from windows

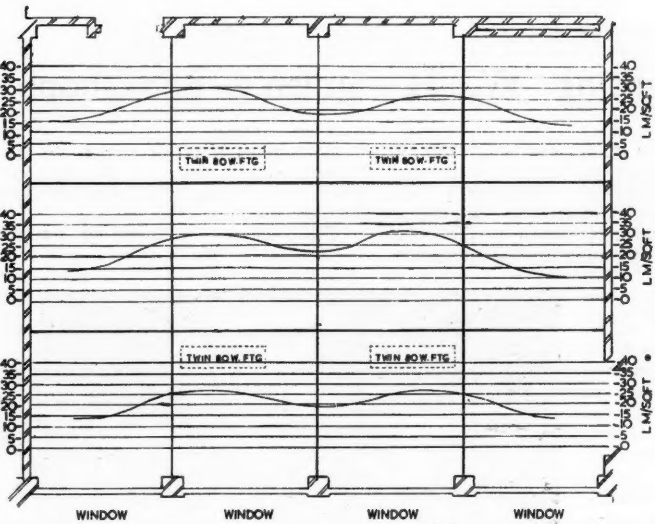


Fig. 6. Showing levels of artificial lighting in the prototype classroom.

only, from top lighting only with louvres open, and from a combination of both. It will be apparent that the effect of the top lighting is to raise the daylight factor all over the room. In the centre of the room it is increased more than six times, whilst in even the worst served parts of the classroom the increase is from less than ½ per cent. to about 3 per cent.

Under these conditions, and by the use of the adjustable louvres, brightnesses within the classroom are more readily controlled. The amount of light falling on the chalkboard would probably be adequate under all but winter sky conditions.

Artificial Lighting

Four louvred fittings, each with two 80-watt daylight fluorescent lamps, are installed in the classroom and give an illumination varying between just over 10 and 30 lm/sq. ft. A truer representation of the illumination over the classroom is given in Fig. 6, which shows the illumination at floor level. Supplementary lighting for the chalkboard is given by three 30-watt daylight lamps which give 30 lm/sq. ft. on the chalkboard. Each of the three lamps may be switched independently to concentrate attention on any particular part of the board. The switches are situated conveniently near the board.

Instant start gear is incorporated in the fittings, which are designed so that lamps may be changed by lifting them over the louvres which are left in place. The fittings were designed by the County Architect's Department and manufactured by Messrs. F. H. Pride, Ltd.

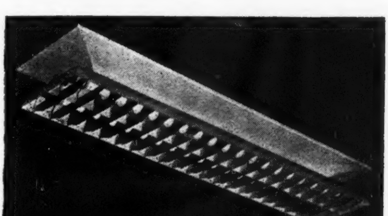


Fig. 7. The lighting fitting used in the classroom.

Anodised Aluminium in the Construction of Lighting Fittings

(*Continued from p.* 304)

Rotax, Ltd.; Fig. 3 by permission of Leysfield Engineering Co., Ltd., and Fig. 4 by permission of C.W.C. Equipment, Ltd.

Technical data for this article was provided by the library of Alumilite and Alzak, Ltd., from whom detailed references may be obtained.

Relighting W. H. Smith's Bookshops

Messrs. W. H. Smith and Son, Ltd., are now carrying out the relighting of their bookshops throughout the country and changing from tungsten to fluorescent lighting. A recent provincial installation is that at their Corporation-street, Birmingham, premises, two photographs of which are shown on this page.

This installation was planned by illuminating engineers of Siemens Electric Lamps and Supplies in close collaboration with Mr. W. G. Norris, architect to Messrs. W. H. Smith and Sons, Ltd.

The level of illumination desired was between 16 and 20 lm./ft.^{2}. The height of the ceiling on the ground floor varies between 20 ft. and 10 ft., so that particular attention had to be paid to siting in order to obtain an even illumination over the whole floor.

W. H. Smith & Son's Corporation Street, Birmingham shop showing the recently installed fluorescent lighting. *(Above)* The ground floor book department. *(Left)* The first floor library.

In changing from tungsten to fluorescent lighting careful attention also had to be given to the wiring, which was incorporated into the panelling of the ceiling.

The colour of the fluorescent tubes used is warm-white, which it is found is most satisfactory in bookshops where in addition to books, general stationery and other goods are sold and where seasonal displays of books are arranged.

Eye Movement Research

Account of recent work at the Imperial College and elsewhere

By MARY P. LORD and W. D. WRIGHT

How far a knowledge of eye movements should be regarded as an essential item in the qualifications of an illuminating engineer is a matter for argument, but of its relevance as an ancillary subject there can be little doubt. Eyes in use are continually on the move. Does it matter how they move? Does the design of the lighting installation affect the movements anyway?

It is easy to speculate about the answers to these questions. In reading, we know that the eyes move across the line of print in a series of jumps. The actual perception of the print occurs during the fixation pauses and sometimes the eyes make a regression when the reader has some doubt about a word or when a passage has been difficult to assimilate. In poor lighting, the reading speed is reduced; according to Tinker (1946) an increase in the duration of the pauses is mainly responsible.

Again, high-lights are generally considered to draw the gaze and it is possible that the irritation and discomfort of a glaring light are partly due to the effort required to overcome the tendency to glance at it repeatedly. Moreover, it may well be that riveting the eyes on a particular object for any length of time may not be a good thing visually. If so, the practice of spot-lighting some feature of a machine might require modification.

In playing games, the accurate hitting of a ball requires a quite remarkable neuromuscular co-ordination, but the initial information on which the co-ordination is based comes primarily through the eyes. The judgment of the position in space of a rapidly moving ball is reached while the eyes are engaged on a rapid pursuit movement, during which the visual axes are believed to follow the ball in a more or less smooth and continuous sweep. Good lighting is unlikely to convert a rabbit into a Compton, but any factor which assists us to keep our eyes on the ball is likely to increase the total on the scoreboard.

The need for eye movements arises, of course, from the fact that, unlike the camera, in which the grain of the emulsion is effectively uniform over the whole of the plate, the grain of the retina is finest in the central area, especially at the fovea, and relatively coarse in the periphery. Perception of fine detail is, therefore, only possible when the eyes are rotated to focus the particular point under observation on the fovea.

It appears unlikely that the eyes can ever be held absolutely steady, and it is possible that the perception of detail is essentially a dynamic rather than a static problem; existing knowledge of the electrophysiological response of the retina is consistent with this. But all these speculations get us nowhere, unless we have some factual information about the eye movements themselves.

Methods of Investigation

Various methods of studying eye movements have been devised, the study of after-images providing much of the classical information on the subject. After gazing steadily for a minute or so at, say, an illuminated cross, the after-image of the cross is observed against some uniform background, and from the orientation of the cross when the eyes are looking in different directions, a good idea of the apparent torsion of the eyeball can be deduced. Movements of the after-image during fixation give an indication of the steadiness of the image on the retina, but there is some doubt as to how far the presence of the after-image may affect the observations.

All the objective techniques for studying eye movements yield information about the movements of the front of the eyeball only. In order to deduce the movement of the eyeball as a whole and the movements of the retina relative to the image of the object of regard, various assumptions are made: for example, that the position of the centre of rotation is known, and that the optical properties of the eye undergo no change during the observations. The validity of the various assumptions is still a matter for discussion.

Quite a lot of general information can be obtained simply by watching a person's eyes. The saccadic movements in reading, the continuous movement when a person in a moving train keeps his eye on some feature of the passing scenery, the quick saccadic glance round a room to recognise the people

present, can all be observed quite readily. For a systematic investigation, however, some more permanent record is required; while, for studying small movements, direct observation is not sufficiently sensitive, since, for a rotation of 1 degree, a point on the eyeball moves round by only 0.2 mm.

Ciné-photography of the eyes can be used to record the larger eye movements, and Karslake (1940), in the United States, has attempted to study the attention value of advertisements by this method. Photography of the virtual image of a light source formed by reflection in the cornea—the so-called corneal reflex—has been used extensively to study eye movements in reading. The American Optical Company have produced a portable ophthalmograph on this principle, giving a photographic record of the horizontal movements of both eyes, and although the smallest movements that can be accurately recorded are of the order of one or two degrees, this is quite adequate to study the fixation pauses and regressions during reading for various observers and conditions of observation. Hartridge and Thomson (1948) have elaborated the corneal reflex method to investigate eye movements during fixation and find that, within the sensitivity of their apparatus, the eye does not move during continuous fixation.

An entirely different technique makes use of small changes in potential difference that have been found to occur between points on the skin above and below the eyes when the eyes look up or down, and between points on either side of the eyes when they are turned to left or right. The potential changes are very minute, but when sufficient care is taken with the electrical contacts to the skin, measurable signals can be obtained which, after amplification, give a continuous record of the eye movements. The method has the advantage that there is no need to fix the subject's head, and as Carmichael and Dearborn have show in their book on "Reading and Visual Fatigue" (1948), it is a very successful technique for studying the relatively large movements involved in reading.

Fixation Movements

To record rotations as small as a minute of arc or less, more refined techniques are required. One method has been to attach a small mirror to the anaesthetised eye and record the deflections of a beam of light photographically. By this means, Adler and Fliegelman (1934) claim to have shown that during steady fixation, the eye was in fact subject to small oscillations of about two minutes of arc superposed on occasional larger digressions. Quite recently Riggs and Ratliff (1949) have reported experiments using a contact lens—a thin transparent cap fitting over the cornea—to which a small mirror has been attached. They found not only an eye "flutter" of about 18 seconds of arc, but also irregular movements of several minutes, together with some drift and compensatory jumps, all occurring during apparently steady fixation.

Research at Imperial College

At the Imperial College, Lord and Wright (1948) have obtained records using a system developed by Lord (1948), in which an ultra-violet beam is reflected at the cornea, the reflected beam being subdivided into two parts by a half-aluminised mirror. One component is partially intercepted by a vertical straight-edge and the other by a horizontal straight-edge. Movement of the eye causes a deflection of the reflected beam, and movements in the horizontal and vertical planes are signalled by variations in the amount of radiation passing the two straight-edges. Electron multiplier photocells are used to collect the varying flux in the two beams, and, after amplification, the output from each cell is connected to the vertical deflecting plates of a cathode ray oscillograph. The vertical and horizontal movements of the eye are thus reproduced by the movements of the cathode beams in the two tubes and these are photographed simultaneously on a film moving at constant speed in a horizontal direction.

One of the problems in this type of work is the reduction of head movements to a minimum, otherwise there would be very considerable confusion between head and eye movements. In the present work, the observer lies on his back with his head resting on a firm foundation and partially supported in a sling; he also bites on a dental impression mounted above him. The residual head movements appear to be reduced to less than 0.01mm. and, as shown from records obtained using an artificial cornea attached to the teeth, are periodic in nature and evidently correspond to the displacement of the body resulting from the heart beat. This is fortunate, since it enables allowance to be made, where necessary, for the head movements, although it is realised that the artificial restraint of the head and the unorthodox position of the observer introduce somewhat abnormal conditions into the experiment.

A typical record obtained during apparently steady viewing of a fixation target is

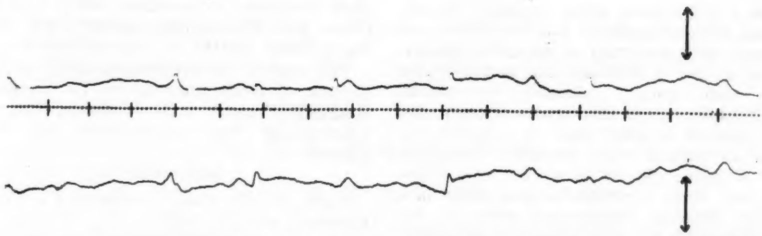


Fig. 1. Eye movements of M.P.L. during fixation on the centre of a cross. Amplitude shown at side; height of arrowed line represents 20 minutes of arc.

In all the figures, time (increasing to right) is marked by dots 50/second and by lines at 1/5 second intervals. Upper record corresponds to vertical, lower record to horizontal eye movements.

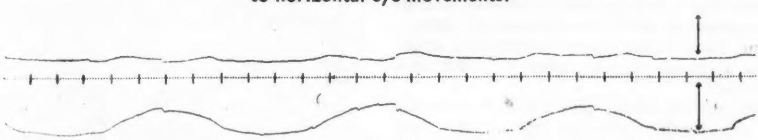


Fig. 2. Eye movements for W.D.W. when following a swinging pendulum. In this and all subsequent figures, the height of the arrowed line shown at the side represents 2 degrees.

shown in Fig. 1. For this observer (M.P.L.), the eye appears to make a flick of several minutes of arc once or twice every second, and, after each flick, to take up a slightly different direction. Between the flicks, however, practically all the movement can be attributed to head movement.

In a modified form of the apparatus (Lord and Wright (1949)), the straight-edges have been replaced by neutral density photometer wedges. This reduces the sensitivity of the system, but has enabled bigger angular movements of the eye to be recorded. Fig. 2 shows the pursuit movement of the eye when following a fixation target attached to a swinging pendulum. It is interesting to compare this with the quite different saccadic movement shown in Fig. 3 recorded when the subject (W.D.W.) was making slow sweeps backwards and forwards between two stationary fixation targets. So far as the subject was concerned, his eye movements appeared to be as smooth and continuous as when following the moving target, but the record indicates that this was far from being the case.

Although we have not been especially concerned with reading movements, we have

Fig. 3. Eye movements for W.D.W. during slow sweeps between two fixed points separated by 2½ degrees.

Fig. 4. Reading eye movements for M.P.L. A downward displacement on the film corresponds to an upward movement of the eye.

made a few records when reading a passage whose angular length of line was about five degrees, with one result of particular interest. Thus, in Fig 4, although the record shows the well known saccadic movements horizontally, yet in the vertical direction the eye appears to show signs of a continuous drift downwards while travelling along the line of print. So far as we are aware, this has not been reported before, partly, no doubt, because instruments such as the Ophthalmograph only record horizontal movements, while the corneal-retinal potential method is probably not sensitive or stable enough to show the drift. The drift is of considerable interest in relation to the size of the fixation field used in reading and as an indication that a continuous eye movement may, under some conditions, occur even when no moving target is in the field of view.

The subject of eye movements is evidently of considerable inherent interest and may prove of no little practical importance. It is quite likely that some of the simpler methods of studying the movements will yield interesting information, and it is to be hoped that illuminating engineers will feel the problem worthy of their attention.

The research in progress at the Imperial College is being financed by the Medical Research Council, and we should like to acknowledge our appreciation of this support.

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Colour Science in America

The meeting of the Colour Group held on September 28 was a delightfully informal affair. It was held in the Staff Common Room of the Imperial College Union, and the first item on the agenda was tea, enjoyed by the members who made themselves comfortable in arm-chairs for this and the following business which was to listen to a visitor from the U.S.A. He was Dr. E. J. Stearns, of the American Cyanamid Company, who gave a most interesting account of the Inter-Society Color Council and its work. This body has a certain resemblance to the Colour Group, in that it studies colour problems in all the spheres in which colour is of vital importance, but it differs from its British counterpart in that, while this is sponsored by a single society, the Physical Society, with other bodies coming in by way of additional membership, the Inter-Society Color Council is autonomous and is formed by the co-operation of a number of societies although not a part of any one of them. Dr. Stearns said that there were 19 societies represented on the Council and a number of individual members who did not belong to any one of these societies. A meeting was held annually, but members were kept in touch with the work of the Council by means of a news-letter every two months. One of the Council's continuing activities was to assist societies who were interested in colour problems to hold special symposia on the subject. Help was given in arranging the programme and in the provision of speakers.

Many of the problems put up to the Council, said Dr. Stearns, were referred to a recognised authority, but if a problem had a wider interest a committee was appointed to deal with it. An outstanding example of this was terminology. Others were the specification of colour aptitude tests, the use of tests for colour blindness, the conditions most suitable for carrying out colour matching in the textile industries and so on. Dr. Stearns then went on to give some details of the system of colour naming being evolved by the Council. There were 26 hue names, and 15 adjectives which could be applied to these; the scheme was founded on the Munsell system. An investigation had also been carried out to determine the conditions of illumination most popular with colour workers.

The address was followed by an informal discussion in which points of similarity of or difference between the I.S.C.C. and the Colour Group were brought out, and various matters of common interest were mentioned.

Off the Record

"Never," said the well-primed speaker, warming to his subject, "never let us forget that we need lumens for lumenity as well as lutility."

An Integrating Photometer For The Measurement of Light Output of Flash Tubes

By D. L. MUNDEN,* B.Sc.

A description of the apparatus and circuit.

Introduction

In general most light sources are designed to give a constant light output over long periods of time. For certain applications, however, a light source of an intermittent nature giving a high instantaneous light output is necessary. Developments in this field have occupied many years, but the most rapid progress has been made during recent years. During the last decade rare gas flash discharge tubes have found extensive use in a large variety of photographic applications and in the visual examination of high speed phenomena by stroboscopic methods.

It has become increasingly important during research on flash tubes to develop an accurate and quick method of measuring the total luminous output from the tube. The apparatus described has been designed specifically to perform this function.

Characteristics of Gas-filled Flash Tubes

General

Gas-filled flash tubes have been made commercially in this country since 1942, when they were developed as a high-power light source for use in aerial photography for military purposes.

Fig. 1 shows the construction of a typical tube. It consists essentially of a narrow glass tube with two tungsten electrodes sealed into the extreme ends of the tube and filled with a rare gas, usually argon, krypton or xenon. A third terminal, the trigger electrode, is connected to a wire wrapped round the outside of the tube.

The standard circuit for the operation of tubes of this type is shown in Fig. 2(a). Condenser C_1 is charged to a high voltage E_1 (usually 2000v.). The lamp is designed to possess a break-down voltage greater than E_1 so that no discharge of the condenser occurs. On the operation of switch S_1 a high voltage pulse is applied to the trigger electrode, causing the gas to ionise, and the breakdown voltage of the tube to drop below the value of E_1. Condenser C_1 then discharges through the tube accompanied by a bright flash of light.

The light output from a source of this type is of very short duration and very high instantaneous intensity. A curve for the light output of a typical flash tube operating on 25μ fds. at 2000v. is shown in

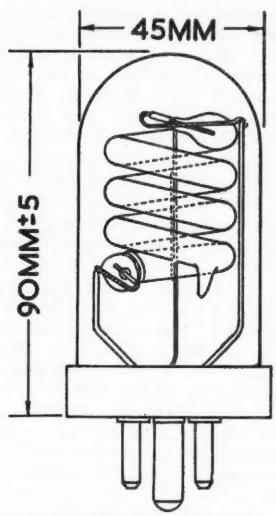


Fig. 1. Diagram of S.F.3.

Fig. 3. It may be noted that the peak intensity is of the order of 10,000,000 lumens, but the total duration of the flash is not longer than 1/4000 sec.

Integrated Light Output

The standard practice for the measurement of the luminous flux from light sources which operate continuously, is to insert the lamp inside a photometer sphere, and to measure the resultant current from a photocell when illuminated by the source. By comparison with a known standard source the light output of the lamp may be deduced.

This method is inapplicable to the

* Research Laboratories, Siemens Electric Lamps and Supplies, Ltd.

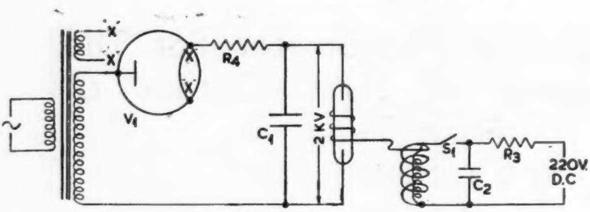


Fig. 2(a). Circuit for flash tube operation.

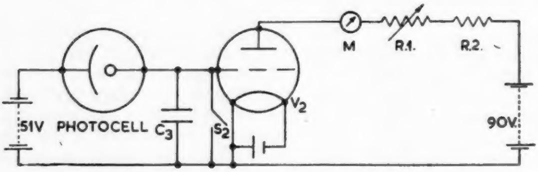


Fig. 2(b). Integrating measuring circuit.

measurement of the light output from a flash tube. Firstly, such a method could measure only the instantaneous intensity of the source, of academic interest, but very little practical value. Secondly, as the light is of such short duration, the inertia associated with the movement of the meter would prevent an accurate reading even at that value.

At ordinary shutter speeds, it is a well-known fact that the photographic effect upon a film is approximately a function of the total integrated light incident upon the film.

It has been found experimentally that except for flashes of extremely short duration (1-10 microseconds) any deviation from this rule due to the extreme shortness of the flash, is of second order importance only. In the case of the flash tube, the whole of the light from the lamp is employed in obtaining the photograph and hence the photographic effect is related to the light intensity integrated throughout the duration of the flash.

The integrated light from a light source over a period of time is measured in lumen seconds, where a lumen second is defined as the quantity of light equivalent to a light flux of one lumen lasting for one second.

The integrated light output from the flash tube is therefore $\int I dt.$ lumen seconds, a parameter of great importance, as the visual and photographic effect of the flash are directly related to this value.

This value may be obtained by the summation of the area under the light output curve as given in Fig. 3. As might be expected for an effect of such short duration, a very accurate trace of the light output is difficult to obtain and, as the tail off of the curve is very gradual, the difficulty of accurate summation is greatly increased.

The method and apparatus described below have been designed to perform a measurement of this integrated light output quickly and accurately.

Efficiency of Flash Source.

By obtaining a value for the integrated light output from the light source the

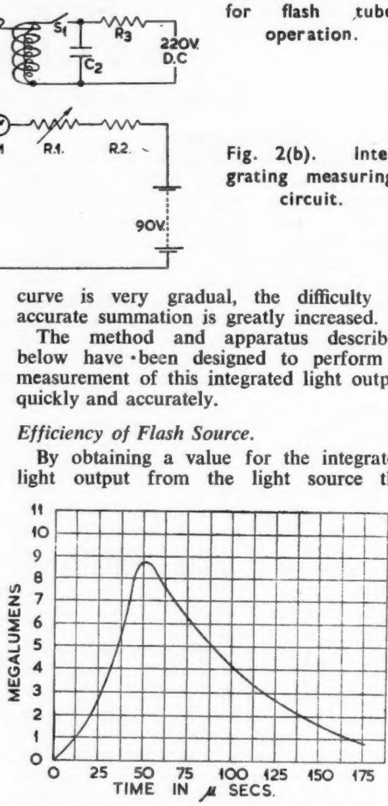


Fig. 3. Light output curve for S.F.3.

efficiency of the source can also be directly deduced.

Thus the electrical energy supplied to the lamp in Fig 2 (a) $= \frac{1}{2}C_1E_1{}^2$.

If the lumen second output is L lumen seconds

Efficiency of the lamp $= \dfrac{L}{\frac{1}{2}C_1E_1{}^2}$ lumen seconds/watt seconds.

Principle of Operation.

A complete circuit diagram of the apparatus is shown in Fig. 2 (b). The flash tube operating circuit has already been

described. A photometer sphere, coated internally with a matt-white gelatine paint with high reflecting coefficient, is employed. In apparatus of this type, the light source is located at the centre of the sphere and the photocell on the circumference, shielded from direct light from the light source by a matt-white screen. If the dimensions of the light source are small compared with the diameter of the sphere, the intensity of illumination will be approximately uniform over the circumference of the sphere. Under these conditions the current from the photocell will be proportional to the intensity of illumination and will give an accurate measurement of the light output from the source.

The principle of the integrating measuring circuit is extremely simple. The current from the photocell, resulting from the incident light falling upon it, charges up the low-leak condenser C_3. The final voltage built up on this condenser is proportional to the total quantity of electricity from the photocell throughout the flash, which is itself proportional to the total light from the flash source. Thus the final charge on the condenser is proportional to the integrated light from the flash tube. The valve V_2 is used as a single stage D.C. amplifier. A change in anode current from the valve indicated on the meter M, gives an amplified measurement of the change in grid potential.

In this way, when the cell is illuminated by a continuous source, a steady fall in anode current will be observed, due to the gradual charging of condenser C_3; when light from a flash is incident upon the photocell, a sudden change in anode current will occur.

The apparatus may first be calibrated by observing the change in anode current with time, when the photocell is illuminated by a continuous source of known lumen output. From these readings a graph of meter deflection against lumen seconds can be directly deduced. A typical calibration graph obtained with a continuous source of 82.5 lumens output is shown in Fig. 4. The instantaneous deflection produced by the flash may then be directly applied to the graph to give the lumen-second output of the flash source.

After the readings have been taken the circuit may be restored to its original condition by discharging condenser C_3 by means of switch S_2. The variable resistance R_1 is used to limit the initial anode current through the valve to any desired value.

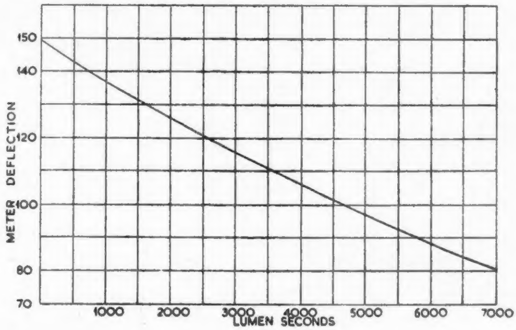


Fig. 4. Graph of meter deflection against lumen-seconds.

Circuit Design Details.

From consideration of the circuit, it is apparent that a small change in grid voltage, due to extraneous causes, will cause a considerable drift of the meter and will make impossible accurate observation of the deflection. In order that accurate results may be obtained it is essential for the grid of V_2 to be extremely well isolated from all possible external charging sources.

Change in grid potential may result from:—

(a) Leakage across condenser C_3.
(b) Grid current from the valve.
(c) Dark current from the photocell.
(d) Leakage across the valve V_2.
(e) Pick up on the highly insulated grid from external sources.

Leakage due to all these causes has been encountered during work on the design of the apparatus, and the final circuit is designed to overcome or largely counteract these effects.

(a) The critical component in the circuit is the condenser C_3. The smaller the value

of C_3 the larger the change in grid voltage for a given photocell current, and consequently the more sensitive the apparatus. With a smaller value of C_3, however, the meter drift due to leakage across the condenser becomes more marked. We have found that a condenser of $0.1\,\mu$fd. is the minimum which may be used for the drift to remain inappreciable. In addition, in order that the leakage across the condenser itself may be kept to a minimum, a high voltage condenser possessing a very high internal resistance is required.

(b) The most serious factor capable of causing drift of the meter is the grid current of the valve V_2, and the circuit has been specifically designed to overcome this effect. For the valve V_2 a triode is employed which passes a very small grid current at the normal operating voltages. The grid current/voltage curve is shown in Fig. 5. It will be seen that with a positive grid the grid current is quite large, but a slight negative potential on the grid is sufficient to restrict the grid current to a low value. The integrating circuit is designed to work under conditions of negative grid. Initially the potential on the grid is slightly negative and, on flashing, the grid is driven increasingly negative. In this way, throughout the whole

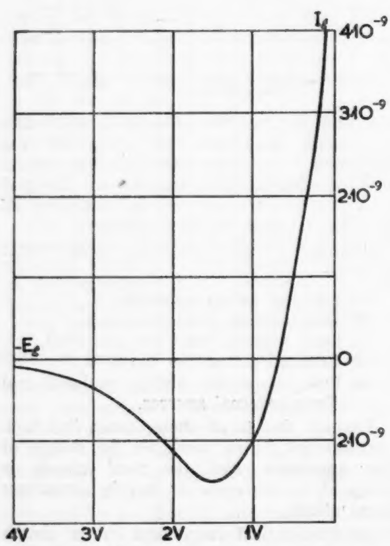


Fig. 5. Valve characteristic I_g against E_g.

operation, the drift on the meter due to the grid current is reduced to a minimum.

(c) The effect of the dark current from the photocell is largely overcome by the choice of photocell. Early photocells which were used gave a serious dark current effect. By careful selection, however, a photocell was found in which this effect was reduced to a minimum. In addition, this effect is reduced by reducing the voltage across the photocell. With a voltage of 50 volts across the cell the dark current is found to be extremely small.

(d) In preliminary work, leakage across the valve base and holder was found to be serious, particularly under damp climatic conditions. For maximum stability in this respect, the highest insulation of the grid terminal is desirable. This is obtained conveniently by use of a valve with the grid terminal brought to a separate cap.

(e) The pick-up effect was found to be remarkably important, a high voltage coil discharging in the same room being sufficient to cause a complete swing of the meter. To overcome this effect it is found essential for all parts of the equipment to be well earthed. This is achieved by painting the base board of the equipment with aluminium paint, and connecting both this and the sphere itself to a good earth terminal.

By employing all these precautions a very stable circuit may be set up allowing accurate readings of the deflection to be obtained.

Photocell and Filter Details

To give reliable readings of the light output of the tubes, a number of essential characteristics must be possessed by the photocell.

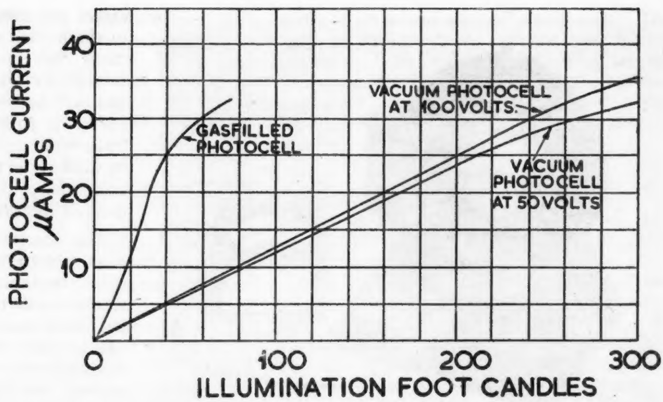
(a) The cell must react with negligible time delay, to the light falling upon it. The approximate duration of a flash being 100 micro-seconds, the response of the photocell must be independent of the frequency of the incident light up to a frequency of 10^4 per second and preferably even higher to follow accurately the build up of the flash.

(b) The cell must have a linear current/light response over a large range of light intensity.

(c) For absolute measurement of the light output of the lamp the spectral response of the photocell must be similar to that of the human eye or, alternatively, capable of correction to this by means of filters.

To conform with (a) and (b) a vacuum

Fig. 6. Current/lumen curve for (i) gas-filled photocell; (ii) vacuum photocell at 50v; (iii) vacuum photocell at 100v.



type photocell is essential for accurate measurements of the light output, as

(i) a barrier layer cell is reliable only at very low frequencies; and

(ii) the presence of the gas in a gas-filled photocell causes a non-linear current/light response. (See Fig. 6.)

The electrical and spectral characteristics of various photocells were investigated and the results obtained with the Cintel VB 39, the type eventually chosen for the equipment, are discussed below.

Electrical Response of the Photocell

It is important that the photocell should be operated in all cases for flash and continuous source over the linear portion of the light intensity/current curve. This characteristic of the cell was investigated and the results obtained are shown in Fig. 6, where the curve obtained with the Cintel VB 39 for two different anode voltages is compared with that for a gas-filled tube. With the vacuum cell the curve remains linear to a maximum photocell current of 25 micro-amps with the lower voltage across the cell and to a slightly higher value at the higher voltage.

These results indicate that it is necessary to restrict the light incident on the photocell at the peak of the flash to a value such that the current passed by the photocell should not exceed 25 micro-amps.

From oscillograph curves for a flash, it is

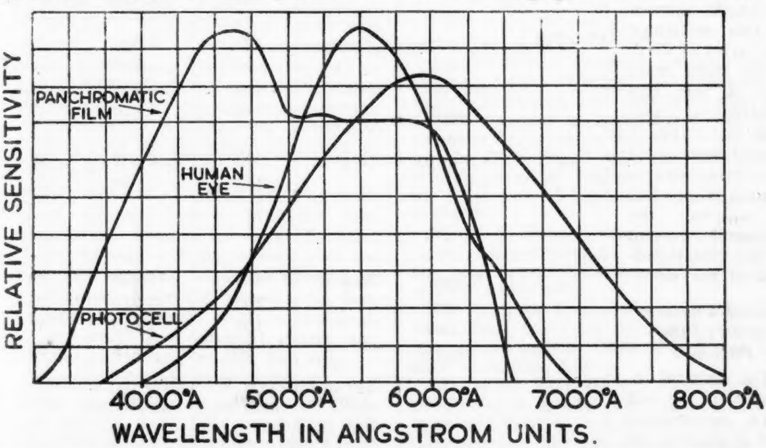


Fig. 7. Spectral curves for (i) Human eye ; (ii) Super XX panchromatic film ; (iii) Cintel VB 39 photocell.

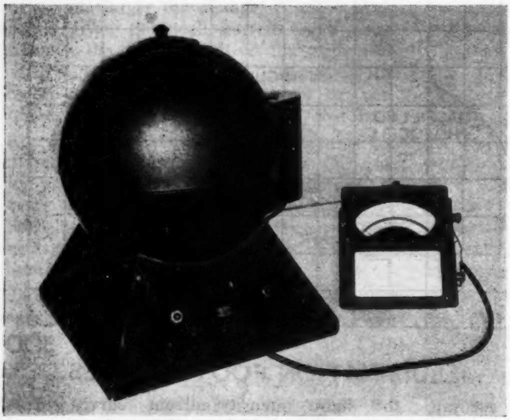


Fig. 8. Photograph of integrating sphere.

known that the maximum intensity of the flash is of the order of 10^7 lumens (see Fig. 3), and to restrict the light to the unsaturated region of the photocell a dense neutral filter is required.

A simple modification of the photocell circuit, where the condenser C_3 was replaced by a 10 megohm resistance, was used to obtain a valve for the necessary filter. Using this circuit with 150 lumens falling upon the photocell, a change in anode current of two milliamps was observed. From these readings it was calculated that under flash conditions a neutral filter of 0.1 per cent. transmission is required to confine the photocell current to the linear portion of the curve.

Spectral Characteristics of the Photocell

The spectral response of the cell was investigated and a diagram of the spectral response of the Cintel cell compared with that of the human eye and panchromatic film is given in Fig. 7. It will be observed that the general nature of all three curves is similar. There are, however,. minor variations, particularly in the red and infrared, where the cell shows a marked increased sensitivity.

The spectral output from a flash tube has been found to be of a continuous nature very similar to that of daylight, and the variations between individual tubes to be very slight. Consequently, in the comparison of the light output from tubes of this type the variations in the spectral response are of minor importance. For the absolute measurement of the light output, however, the spectral response of the cell is of great importance, as the continuous source against which the flash tubes are to be calibrated will possess different spectral characteristics from that of the flash itself.

(*Continued on next page*)

Table I

The Light Output and Efficiencies of Flash Tubes.

Light Source	Tube Dimensions	Gas Filling	Electrical Loading in joules	Light output in lumen-secs.	Efficiency lumen-secs/ watt-secs.
S.F.3	4.5 mms. bore 38 cms. length	Xenon	200	7,830	39
			150	5,630	37.5
			100	3,755	37.5
			50	1,870	37
S.F.3	4.5 mms. bore 38 cms. length	Krypton	200	6,130	30.5
			100	2,920	29
S.F.2	8 mms. bore 62 cms. length	Xenon	400	15,820	39.5
			200	7,370	36.8
			100	3,220	32
			50	1,415	28
S.F.8	3.5 mms. bore 37.5 cms. length	Xenon	100	3,800	38

Description of Apparatus

The photograph of the apparatus, as demonstrated at the recent thirty-third Physical Society Exhibition, is shown in Fig. 8. It consists of a metal sphere of 14 inches diameter, painted on the inside with matt-white gelatine paint of high reflecting coefficient. The photocell is contained in a separate compartment, separated from the main chamber by a dense neutral filter. At the centre of the sphere is accommodation and mounting for the standard type of flash tube, with provision for the substitution of a standard tungsten lamp for calibration purposes. Either of these tubes may be inserted through the lid at the top of the sphere. The power pack for the supply to the flash tube is contained in a separate housing, but all components for the integrating measuring circuit and for the trigger circuit are housed in the base of the equipment. The power supplies are led in through an insulated panel at the rear of the equipment. The meter is attached at the front of the instrument where all the necessary controls for the operation of the equipment, namely, trigger button to flash the lamp, variable potentiometer to set the meter and reset button, are to be found.

On operation the flash tube is inserted in the sphere and the power supply switched on. The reset button is pressed to set the meter and the potentiometer varied until the meter is set to the zero deflection mark. The flash is produced by pressing the trigger button and the resultant deflection on the meter noted. This is applied to the calibration graph attached to the instrument, where the lumen second output of the flash may be read off directly.

Results

Some typical results obtained with a variety of Sieflash tubes under various electrical loadings and filled with different gases are given in Table 1.

It is interesting to observe the increased efficiency obtained with xenon compared with the efficiency of a krypton tube. In addition to this greater efficiency, the fact that the light from a xenon tube is a closer approximation spectrally to that of daylight makes the use of xenon as a gas filling for flash tubes doubly advantageous.

Another point of interest is the increased efficiency obtained with the higher loadings due to the increase in current density. This is emphasised by the more marked increase in efficiency obtained with the S.F.2 with increase in load. Due to the wider bore of the S.F.2, the current density at the lower loadings will be low compared with the S.F.3 and S.F.8. Only on high loadings will the current density reach its saturated value when maximum values for the efficiency will be obtained.

Situations Vacant

Leading (E.L.F.A.) Manufacturers of Electric Light Fittings require experienced DESIGNER-DRAUGHTSMAN. Applicants must be familiar with manufacturing methods, particularly for fluorescent fittings, and be capable of producing detailed manufacturing drawings from appearance designs or specifications. Applications, stating age, experience and salary required, should be addressed to Box No. 801.

DESIGNER-DRAUGHTSMAN urgently required by well-known Midlands firm manufacturing Fluorescent and Tungsten Lighting Fittings. Fully experienced and capable of estimating costs and working on own initiative. Excellent prospects for keen and adaptable applicant. Reply in confidence (our own employees advised) stating age, experience and salary, to Box No. 802.

LIGHTING ENGINEER required in illuminating engineering department of Ekco-Ensign Electric, Ltd., fully conversant with preparations of fluorescent and tungsten lighting schemes. The appointment carries a good salary and is pensionable. Write, giving details of experience, age, etc., to Chief Illuminating Engineer, 5, Vigo-street, London, W.1.

Personal Notes

Mr. S. Poole, formerly manager of the Bristol Branch (lamps and lighting) of Philips Electrical, Ltd., has been appointed branch manager of London and the Home Counties. His place in Bristol has been taken by Mr. D. E. Beard, who has been lighting sales engineer for Philips Electrical, Ltd., in the south-west of England for the past three years.

Mr. J. K. Frisby, who has been with the lighting department of B.T.H. since 1941, has been appointed senior lighting engineer at their Leeds office.

Mr. K. Lee, formerly with Philips Electrical, Ltd., has been appointed sales manager of the lighting division of Thorn Electrical Industries, Ltd.

Mr. R. G. Brandon has given up his appointment as general sales manager of the lamp and lighting department of the B.T.H. Company to take up full-time duties with the Hotpoint Electric Appliance Company, Ltd.

Problems in Illuminating Engineering For Students

By S. S. BEGGS, M.A., F.I.E.S.

3. *Line and Surface Sources*

With the introduction of tubular lamps, such as the long electric discharge lamps, the practical value of being able to calculate the illumination provided by a line source has increased considerably; the ability to calculate the illumination from an extended source has for long been almost an essential requirement of the specialist in natural lighting, as well as of the architectural lighting engineer concerned with large area secondary sources. While any such source of finite dimensions can always be subdivided into a multiplicity of small areas, each of which can be treated as a point source to which the Inverse Square Law may be applied to the required degree of accuracy, often the work can be shortened considerably if one or two of the more important formulae are known. These apply strictly only to theoretical sources of idealised characteristics, such as constant brightness or with a dimension infinitesimally small or infinitely great, and the problem may seem rather academic for this reason. Nevertheless, they illustrate the simplication of the practical problem that may often reasonably be made, and show how the required quantity may be calculated (with sufficient accuracy for most purposes) with a minimum amount of labour.

There are three sets of relationships of importance, viz.: (1) that between light flux and maximum intensity or brightness for *finite* line or plane area source, (2) that between illumination and distance from source for *infinite* straight line or plane area source, and (3) that between illumination and distance from source for a point level with one end of a *finite* line source or one corner of a *finite* rectangular source. (If the point of measurement is not directly opposite one end or one corner of the source, the latter can always be made up of the sum or difference of sources which have this characteristic.) The result is of more importance than the mathematical derivation, though this has sometimes been asked for in the examination, and should not present great difficulty to the mathematically trained student. Some of the simpler formulae which should be known are given below, where—

F = total luminous flux from finite source, in lumens,
I = maximum intensity of finite line or area source in candles,
i = intensity per unit length of line source (assumed uniform) at right angles to its length, in candles per foot length,
L = length of straight finite line source, in feet,
B = brightness of source (assumed uniform over area and constant for all directions of view), in candles per sq. ft.,
A = area of plane area source, in sq. feet,
d = distance of the point of measurement from the source, in feet, and
E = illumination on the specified plane at that point, in lumens per sq. ft.

(1) For uniform point source: $F = 4\pi I$.

For finite straight line source:
$$F=\pi^2 I=\pi^2 i.L.$$
For finite plane area source:
$$F=\pi I=\pi B.A.$$

(2) For point source and plane facing source:
$$E=I/d^2.$$
For infinite line source and plane parallel to and facing source:
$$E=\frac{\pi i}{2d}.$$
For infinite area source and any plane:
$$E=\pi B.$$

(3) The formulae for rectangular sources are important, but are more complex and difficult to memorise. They should be known, if possible, but are rather specialised in their application.

Question 3 (1941)

A 3-foot length of architectural tubular type of electric lamp is set upright, free from any obstructions, with its lower end 2 feet above a horizontal surface. It emits 2,826 lumens.

Determine the value of the illumination on a horizontal surface at 4 feet and at 8 feet from the point on the horizontal sur-

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The first article in this series appeared in Vol. XLII, No. 9, September, 1949.

face directly below the tubular lamp. Derive any formulae used.

Answer

(i) Derivation of Formulae

A uniform linear source of length L feet and intensity i candles per foot at right angles to its length has an intensity ($iL \sin \theta$) in a direction making an angle θ with its axis. The total flux, F lumens, emitted by the lamp is therefore given by

$$F = 2\pi \int_0^\pi (iL \sin \theta) \sin \theta \, d\theta$$

$$= 2\pi \, iL \int_0^\pi \sin^2 \theta \, d\theta$$

$$= \pi \, iL \Big[\theta - \sin 2\theta \Big]_0^\pi$$

$$= \pi^2 \, iL.$$

If this source is placed vertically with its lower end resting on a horizontal plane (Fig. 1), the illumination δE at a point P

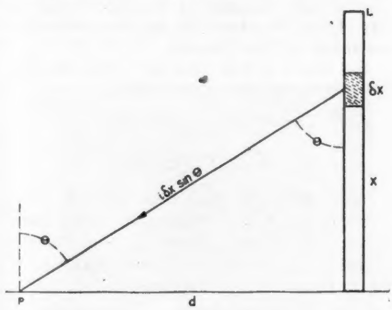


Fig. 1.

in the plane at a distance of d feet from the lamp due to a short length δx at height x above the plane is (by the Inverse Square and Cosine Laws) given by

$$\delta E = \frac{i \, \delta x \sin \theta}{x^2 + d^2} \cdot \cos \theta = \frac{i \, d \, x \ \delta x}{(x^2 + d^2)^2}.$$

Hence the total illumination E at P due to the linear source is given by

$$E = i \, d \int_0^L \frac{x \ dx}{(x^2+d^2)^2} = i \, d \left[\frac{-1}{2(x^2+d^2)} \right]_0^L$$

$$= i \, d \left[\frac{1}{2d^2} - \frac{1}{2(d^2+L^2)} \right] = \frac{i \, L^2}{2d(d^2+L^2)}.$$

If the source is raised so that its lower end is at a height l feet above the plane, it may be regarded as a lamp of length ($L + l$) feet with the lower length l removed. The illumination $E1$ at P is then the difference between the values of E calculated for values of L equal to ($L + l$) and l. Thus

$$E1 = \frac{i(L+l)^2}{2d[d^2+(L+l)^2]} - \frac{i \, l^2}{2d(d^2+l^2)}$$

$$= \frac{i \, d \, L \, (L+2l)}{2[d^2+l^2][d^2+(L+l)^2]}$$

(ii) Calculation of Illumination

For the lamp described L = 3 and F = 2,826, whence, $i = 2{,}826/3\pi^2 = 95.4$. The lamp is placed so that $l = 2$.

At the point 4 feet from the lamp axis ($d = 4$)

$$E1 = \frac{95.4 \times 4 \times 3 \times 7}{2 \times 20 \times 41}$$

$$= 4.9 \text{ lm./sq. ft.}$$

At the point 8 feet from the lamp axis (d = 8)

$$E1 = \frac{95.4 \times 8 \times 3 \times 7}{2 \times 68 \times 89}$$

$$= 1.33 \text{ lm./sq. ft.}$$

Question 4 (1943)

State the laws governing the change in illumination with distance from source for point, line and surface sources. Describe what significance such laws might have in practical problems. What other important properties characterise the three types as practical sources of illumination?

Answer

For a point source the illumination varies inversely as the square of the distance from the source; for the (infinitely long) line source the illumination varies inversely as the distance from the axis of the source; for the (infinitely large) surface source the illumination is constant and independent of the distance from the surface source. For finite sources the law of variation is not strictly any of these, but approximates to one or other according to the relative proportions of the distance of the point of measurement and the dimensions of the source.

At relatively great distances, the illumination from any real source, whatever its shape, varies inversely as the square of the distance. Thus the equilux lines of a trough reflector with tubular fluorescent lamp mounted at usual heights are nearly circles. With long line sources (which may be a row of separate small lamps) the illumination falls off slowly with increasing distance; for example in a long room lighted by unobstructed windows down one long side, the illumination on a vertical surface facing the window at the

far side of the room will still be comparable with that a few feet inside the room. In an indirect lighting scheme, where the whole ceiling is the secondary source, the illumination is almost independent of the height of the plane of measurement; in any large installation, whether the individual sources be extended or "point" sources, such as filament lamps, the *average* illumination will be almost independent of the height of the working plane.

"Point" sources of light give hard shadows, which may be objectionable or may be desirable to give modelling to the object illuminated. The light can be controlled to a high degree by an optical system of reasonable size, thus enabling a high illumination to be provided over a restricted area, as in a spotlight. The source must be bright to give a reasonable amount of light, which may tend to cause glare. A line source gives much greater diffusion, only straight edges parallel to its length producing any noticeable hard shadows; the brightness of the source can be relatively low. A large area source gives no shadow, which may produce rather a flat effect (due to the almost entire absence of modelling) and a feeling of monotony if its brightness is fairly uniform. Recesses in an object are well illuminated, but texture tends to be lost. Its low brightnesses in relation to the illumination its provides reduces the possibility of glare to a minimum, and makes its use very desirable where specular materials are used extensively.

Obituary

PERCY JOHN WALDRAM

It is with deep regret that we announce the death, on November 8, of Mr. P. J. Waldram, an original member of the I.E.S. and a leading authority on daylighting.

Percy John Waldram was born on April 27, 1869. He was best known as a pioneer and a leading authority on daylight and sunlight. He studied it from about 1910, at first in collaboration with the late A. P. Trotter and the late Prof. W. Clinton, and he established the principles of daylight factor and methods of measurement of daylight which are now accepted practice.

He was chairman in 1933 of a committee of the Royal Institute of British Architects upon "The Orientation of Buildings," the report of which is a valuable record of the properties of sunlight. He wrote many papers and articles on daylight to technical journals and societies upon all aspects of daylight and sunlight, particularly as they affect town planning.

In his later years he was afflicted with arthritis, by which he was eventually almost completely crippled; nevertheless he retained his full mental vigour, and actively pursued to the end the subject which he had made particularly his own. He was still engaged in it after his eightieth birthday, when he was confined to bed with several serious complaints and had undergone an operation.

He was a member of the Royal Institution; a Licentiate, a former member of Council and examiner of the R.I.B.A.; Fellow of the Royal Institution of Chartered Surveyors; and a Past Chairman and Vice-President of the Junior Institution of Engineers. He was an original member and Fellow of the I.E.S. and a past member of Council. His son, Mr. J. M. Waldram, is the immediate Past President of the Society.

He leaves a wife and two sons, to whom we extend our sincere sympathy.

Corrigenda

Our attention has been drawn to an error in the text of the article "The Use of Sinusoidal Webs in Plotting Light Distributions from Fluorescent Lamp Fittings," by H. J. Turner, which appeared on pp. 218-221 of the September issue. The angular co-ordinates of points P and P_1, as given on p. 220, do not agree with the marked positions of the points on Fig. 1 (a) and 1 (b).

The correct co-ordinates on p. 220, column 1, should read as follows:—

Line 5: "angles Θ = 61 deg. and ϕ = 48 deg."

Lines 14 and 15: "and θ = 40 deg., then ϕ = 47.6 deg., and Θ = 60.5 deg."

We apologise to the author and to readers for this error.

On p. 261 of the October issue we reported that in discussing Mr. Axford's paper at the A.P.L.E. Conference Mr. A. G. Penny said that Mr. Axford "was going too fast in suggesting a life of 3,000 hours for lamps." Mr. Axford in his calculations had taken an average life of 2,500 hours for discharge lamps, and what Mr. Penny actually said was that he was not going far enough, and suggested that Mr. Axford should have taken a life of 3,000 hours. Our apologies to readers and to Mr. Penny.

Lighting for the Make-up Artist

Use of fluorescent and tungsten lamps

The problem of make-up and its suitability under varying kinds of lighting is a considerable one which taxes not only the woman who uses cosmetics but also the manufacturer who supplies her.

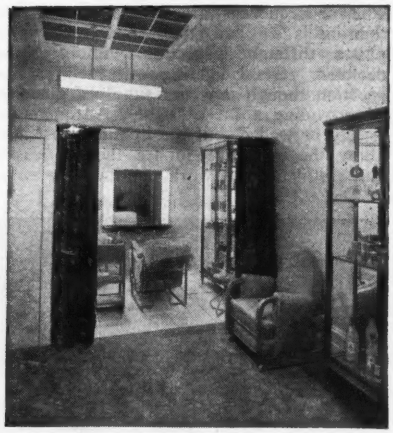
There is, of course, a major distinction between daylight and artificial light which needs to be carefully catered for by correct selection of make-up shades if make-up is to fulfil its function of enhancing a woman's appearance. There is also a big difference between the effect on cosmetic colours of one type of artificial lighting and another. For the woman who may be unaware whether she will be dining in a restaurant lighted by tungsten light and later dancing in a room which has fluorescent lighting, compromise is almost certainly the make-up answer.

Make-up mirror at Messrs. Atkinson's, Old Bond-street, with blended lighting from fluorescent architectural lamps.

The cosmetic manufacturers' problem has a slightly different emphasis although basically it is the same. They must know about, and be prepared to cater for, quite a considerable margin of distortion in the shades of their products when viewed in different lighting.

To this end Messrs. Atkinson's Ltd., of Old Bond-street, who have a finely equipped experimental and test salon, have been collaborating with the General Electric Co., Ltd., for some considerable time in order to find a satisfactory solution.

The result so far achieved is a specially designed mirror in which fluorescent and tungsten lighting are combined. Pure tungsten, it was found, over-emphasised the red elements in the colours of lipstick and rouge, while all normal kinds of fluorescent light under-emphasised them. Hence the decision to blend the two types of light. The mirror is flanked on both sides with panels covered with reeded "Perspex." Each of these panels contains one 3-ft. "natural" fluorescent lamp, and one 3-ft. architectural lamp.



General view of experimental and test salon at Messrs. Atkinson's.

This combination gives a light by which make-up colours can be properly assessed, and enables experimental and test work to be done even after daylight has gone. As a result, make-up carried out under this lighting will have a good appearance under daylight, and also under most types of artificial lighting.

Lighting for Product Finishing

Application to Motor Body Assembly

To ensure high quality finishing the operative must be able to see whether the results required are being obtained. This means that the lighting must be just right for the class of work involved. In some finishing shops poor lighting makes the operatives' task so difficult that an excessive amount of time has to be spent on the job. The consequences are even worse if the lighting is so bad that indifferent work passes through inspection without being detected. Good lighting will facilitate inspection though it is not simply a question of providing a lot of light. Adequate intensity is needed, but the lighting must also allow the operative to see the job easily and distinctly and work continuously without eye strain. Because of the special conditions associated with practically every production process industrial lighting installations should be planned by a lighting engineer competent to study and solve the problems involved.

The first consideration in planning a lighting installation is the type of lamp to be used. Although filament lamps in correctly designed fittings often provide the lighting required, experience in recent years has proved that fluorescent equipment has a very wide field of application—a fact demonstrated by the thousands of installations now in use.

An application of fluorescent lighting to product finishing is shown in the illustration. This installation lights a body assembly and finishing line at Messrs. Vauxhall Motors, Limited, so that dents, bumps or minor imperfections, such as scratches on polished or semi-polished surfaces can be detected easily and accurately. In this class of continuous flow production, imperfect work that is allowed to pass the inspection stage or beyond has to be refinished, either outside the normal schedule, or put back into it by readjustments. As this means higher costs it is an economical proposition to install a lighting system that will ensure that bad finishing can be detected at the appropriate stage.

Lighting the body assembly and finishing line at Messrs. Vauxhall Motors, Ltd.

The visual problems involved in planning

an installation of this type are more difficult to solve than those normally associated with general lighting of an interior, because the work involves horizontal, vertical and sloping surfaces, which may be flat, concave or convex. This means that the lighting must provide for easy viewing of all these surfaces from normal working positions. If an operative has to adopt an awkward posture to detect a blemish he may not bother to look.

Uniform intensity was an important requirement, and for this reason although one side of the line receives daylight the fluorescent lighting is used all the time. The fittings are arranged to supplement the daylight and at the same time give ample illumination after dark. As it was essential to provide the right amount of upward illumination of the ceiling by diffusion to avoid harsh reflection contrasts reflector fittings were selected which had been designed to give an effective diffusion of light and a semi-direct distribution, about 20 per cent. of the light being upwards and 80 per cent. downwards. There is enough upward illumination to avoid a dark tunnel effect and harsh contrasts.

Each fitting is equipped with 80-watt fluorescent tube giving a "daylight" colour, this having been found most satisfactory. To obtain the maximum flashing of car roof-tops and lower door-sides it was found necessary to tilt all the fittings at an angle of from 10 to 15 deg. The installation was the result of joint planning by the electrical maintenance staff of Vauxhall Motors, Ltd., and the lighting engineers of Crompton Parkinson, Ltd. It is a good example of what can be achieved if the visual problems involved are considered from all aspects—especially that of the operatives who are responsible for maintaining a high standard of finish.

Correspondence

Lighting Units

The Editor, LIGHT AND LIGHTING

Sir,—I am interested in the editorial in your October edition of LIGHT AND LIGHTING, wherein it is suggested that the term "Lighting Units" would be an improvement on the present term "Lighting Fittings."

I can't help feeling rather strongly that any extension of the generic "unit," already so much overworked in connection with electrical energy and illumination theory, would tend greatly to obscure the issue instead of clarifying it. It may be that I am rather biased by the fact that I give quite a few lectures during the year on what are entitled "Lighting Units," which make absolutely no reference to lighting fittings, being solely concerned with the definition of the lumen, foot-lambert, etc.

While I appreciate that this in itself constitutes no reason for an alteration in what may be an official point of view, I still maintain that we are going to lose control of the word "unit" unless we hold it rigidly to what appears to be its proper use, namely, the fundamental units of measurement.

It is usual when offering somewhat destructive comment to offer a constructive alternative; I find this a little difficult, as I dislike with equal intensity both the term "Lighting Fitting" and "Luminaire," but of the possibilities lying before us I would prefer a single term akin to luminaire but considerably less pompous.—Yours, etc.,

London, W.C.2 W. ROBINSON.

The Editor, LIGHT AND LIGHTING

Sir,—No doubt the powers that be gave very earnest thought to the matter before deciding that foot-candles should retire in favour of lumens per square foot, but I wish they would think again.

I suppose the main reason for the change is that lumen per square foot is supposed to be more descriptive of what the unit is. Well, is it? Is a lumen any easier to visualise or explain than a candle? And look at the offspring of these terms. Equivalent foot-candles can just be managed, but equivalent lumens per square feet (or is it foot?) is so much of a mouthful that a foot-lambert, I believe, is used instead. Is the nature of a foot-lambert easily understood from its name? And if foot-lambert is an acceptable term, why is foot-candle not so? Shall we now have iso-lumens-per-square-foot diagrams?

Some of us have almost grown up with foot-candles and could recognise them. Even outsiders had begun to mention them, which was a good thing for lighting, but a change of name only seems to make things more difficult all round.

Of course, I appreciate the fact that in these days I must have what my masters consider good for me. My beer and cheese and pickles, for instance, have become vitamins, or carbohydrates, or chlorophosphates, or other windy terms designed to fog some issue or other. But I don't want to be fogged. I want foot-candles.—Yours, etc.,

London "DIMWIT."

New Lighting Installations

Cold Cathode Lighting in a Bank

A decision to install cold cathode lighting in the American Room at the 196a, Piccadilly, branch of the Midland Bank, Limited, presented a problem with respect to the blending of the tubes with the architectural design. The ceiling, the work of the late Sir Edwin Lutyens, is decorated at each end with elaborate mouldings enclosing a series of rectangular recesses. In the new lighting scheme the main illumination comes from tubes arranged round the inside of these recesses behind a "Perspex" enclosure, while indirect lighting from a single run of tubing round the cornice gives further relief to other ceiling features.

Two sections of tubing are installed in each rectangular recess, the electrodes being turned upwards into the ceiling in order to achieve a single continuous line of light. The sections are enclosed in reeded "Perspex" bends, sprayed ivory, and mitred at the four corners, the joins being concealed and the bends held in place by brass straps finished real bronze colour.

Three of these rectangular lighting features

(Above). A private office in the bank using the same style of lighting.

(Left). Showing cold cathode tubes behind 'Perspex' covers over the counter.

are over the counter at one end of the room and a further three are at the opposite end of the room, which is divided up into private offices. The walls and panelling are of oak, the colouring of which is shown to advantage by the intermediate white cold cathode tubes.

This room, called the American Room, serves as a West End office of the Midland Bank, Overseas Branch, and handles transactions with visitors from all over the world.

The lighting was planned by the General Electric Co., Ltd., in collaboration with the architects, Messrs. Whinney, Son and Austin Hall, and under the general direction of Mr. F. Fowler, manager of the Premises Department, and Mr. W. H. Murray, chief electrical engineer, the Midland Bank, Limited.

The contractors for the lighting installation were Messrs. Bell Bros. and Co. (London), Ltd.

The interior of Pearks Dairies new 'help yourself' grocery store at Kenton, Middlesex.

A Grocery Shop

On October 6 Pearks Dairies, Ltd., opened a new grocery and provisions store at Kenton, Middlesex, which is claimed to be the first "Help Yourself" grocery shop in England, and if the very considerable interest shown already is any criterion, others must quickly follow.

The store has been specially designed by the company's architect, Mr. Joel Williams, L.R.I.B.A., who has undoubtedly concentrated on the utilisation of space as well as achieving a very attractive appearance for a store designed to facilitate the shopper's task. The customer helps herself—or himself—collecting the purchases in a special basket provided by the store, payment being made and points taken at desks situated inside the exit.

For the general lighting, fluorescent fittings specially designed by the Benjamin Electric, Ltd., in co-operation with Mr. Williams, have been installed by the electrical contractors, Messrs. Pinching and Walton, Ltd. The fittings, seen in the photograph, are totally enclosed ceiling type, with white metalwork. They each house two 40-watt fluorescent tubes with control gear. The fitting is made in three parts—chassis complete with frame for mounting to ceiling, removable quickly detachable gear plate and hinged front, which is arranged for easy detachability and to gain access to the fluorescent tubes. The sides are sloped so as to avoid any collection of dust—cleanliness and hygiene being the keynote throughout. The fitting is glazed on the sloping sides and the front panel with a special diffusing glass of high efficiency.

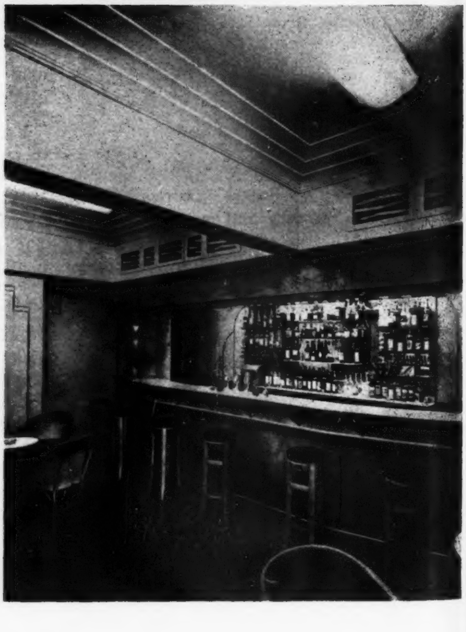
Hotel Lighting for Visitors' Comfort

Guests at the Queens Hydro Hotel, Blackpool, will have noted a pleasing new fluorescent lighting scheme which has been installed recently in the dining room and cocktail bar.

In the cocktail bar, two fittings are used, ceiling mounted at approximately 11 feet. Some concealed lighting is also incorporated, bare 5-ft. 80-watt fluorescent lamps being mounted behind a deep girder which divides the bar itself from the public area.

Throughout this installation, where the fittings make use of "Perspex" diffusers, these have been colour - sprayed to a light peach colour. The contractors were Messrs. Nelson Bros., Ltd., of Blackpool, and the lighting equipment was supplied by the B.T.H. Co., Ltd. In view of the importance of attracting overseas visitors, it is of special interest to note efforts of this kind to make our hotels more attractive.

(Above). The dining room.



Below). The cocktail bar at the Queen's Hydro Hotel, Blackpool

The dining room installation makes use of two types of fluorescent lamp fittings having moulded "Perspex" diffuser covers to promote even light distribution. Eight of these are mounted flush on the ceiling, with control gear remote, at a height of approximately nine feet above floor level. Nine others are at approximately 11 feet mounting height. The fittings are designed to accommodate two 5-ft. 80-watt fluorescent lamps. The general appearance of the relighted dining room is very pleasing.

Continuous Fluorescent Troughing

Description of the Benjamin System

In one of our earlier issues this year we published the first picture of an installation of continuous troughing. No information regarding the system was given at the time but is given below in response to a number of requests .

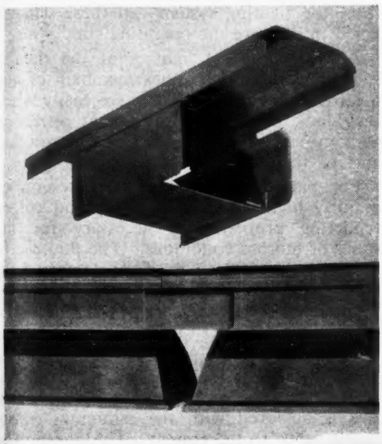


Fig. 1. Top—coupling piece. Bottom — coupling piece in position.

It is one of the features of the latest Benjamin Fluroliers that they can now be installed in continuous runs making an unbroken line of light, often useful in the industrial sphere and where structural conditions make it desirable.

The continuous troughing is accomplished by means of a special coupling piece (Fig. 1) to link adjacent wiring channels. The end panels of the wiring channel are removed at each coupling and the coupling piece then engages in the channel (Fig. 1) where it can be locked in place giving a rigid assembly.

One advantage of this continuous troughing is that the mains wiring can be looped from fitting to fitting inside the troughing after the fittings have been erected, thus saving installation costs.

The alternative methods of mounting are:—

(a) by conduit drops.

(b) by chain.

(c) by screwing direct to a flat surface.

Fig. 2 shows a recent example of this form of lighting which also demonstrates the high degree of alignment which can be obtained with a large number of fittings. This is an installation of type "FF" Fluroliers each with one 80-watt 5-ft. lamp at the new Birkenhead clothing factory of Messrs. L. Harris and Co.

Fig. 2. An installation of continuous troughing in a new clothing factory in Birkenhead. No local lighting is used, the illumination at the sewing machines being over 40 lm/ft^2.

I.E.S. ACTIVITIES

Hospital Lighting

A paper on this subject was given by M. W. Peirce and D. J. Reed at the London meeting on November 8. The paper discussed special lighting requirements in hospitals, together with some of the ways in which these needs can be met. The lighting of operating theatres was considered in some detail, and an attempt was made to classify systems of lighting according to their suitability in different surgical operations.

Each piece of equipment in a hospital should contribute something, either directly or indirectly, towards the treatment of the patient, and without doubt the lighting installation ranks high in importance among such equipment. In wards and corridors the prime consideration should be the comfort of the patient, whether he is lying in bed or convalescent. Attention to the brightness contrast and to the position of the lighting sources will go a long way to ensuring this comfort.

The requirements of the medical and nursing staffs in the wards should be met by additional lighting equipment, either portable or permanent; the patient usually wants a diffused light of a comparatively low level, but the examining nurse or doctor needs a much higher directional illumination.

So far as the lighting for surgical operations is concerned, it is thought to be convenient to classify them into four main groups.

(1) Surface operations, and operations where there is no particular cavity.

(2) Operations on deep-seated organs that can be brought to the surface for examination.

(3) Deep cavity operations where the initial incision is large.

(4) Deep cavity operations where the initial incision is small.

Various fittings and systems for lighting operating tables are mentioned and the suitability of each for particular operations is assessed.

Besides optical suitability, a lighting fitting for use in the theatre must satisfy certain other requirements. The colour rendering of the light source must be such that the surgeon and anaesthetist have no hesitation in assessing the condition of the patient. The comfort of the surgeon must be considered, as he is working at a high pitch of mental and physical tension. The control of heat from the light, the reduction of excessive contrasts, the elimination of direct glare from the lighting system—all these will do much to improve the operating conditions.

Adequate general lighting of the theatre is important so that other members of the theatre team may be able to see easily when they look away from the bright operating area to perform some other task in another part of the theatre.

For pathological work, the provision of a fairly high intensity light of good colour rendering properties is necessary for the study of morbid conditions. The fluorescent lamp would seem to be a satisfactory light source for this purpose, though directional lighting may be necessary where the slight surface irregularities of tissues are sought.

The main requirements of dental lighting are firstly to give the surgeon adequate lighting for his work, and secondly to ensure that this is achieved with the minimum of inconvenience to the patient. The question of colour and shadowlessness again arises, and for psychological reason, simplicity is desirable. Intensity within the mouth must be such that adequate light will result after redirection by a small mirror.

A brief reference was made to the lighting of hospital museums, where the main problem is to enable specimens (usually in glass jars) to be seen without reflections of light sources, if possible, on the surface of the glass.

Leeds Centre

The Leeds Centre opened their sessional programme with a public lecture to an audience of 250 on Light, Colour, and the Stage, by Mr. E. E. Faraday, who demonstrated the nature of the stage lighting engineer's work.

A number of entertaining and amusing demonstrations were carried out to show how colour and shadows help in vision. A novel feature of the lecture was a demon-

stration of the effect of different coloured lighting on a number of dresses shown by mannequins.

Manchester Centre

A meeting of the Manchester Centre held jointly with the Manchester Geological and Mining Society attracted an attendance of approximately 90. In opening his talk Mr. Quigley referred to the need for improved amenities in the mines and the way fluorescent lighting could help in this. Some experimental installations had been carried out but fluorescent fittings were not allowed in the mines where any gas is present, the difficulty being the means of connection to the main electricity supply and lack of any British Standard Specification for "Perspex." Mr. Quigley described the experiments which had taken place at Binley Colliery and Birch Coppice Colliery, and showed a sample fitting.

The discussion was opened by Mr. Edmunds, Past-President of the Institution of Mining Engineers, who suggested that the price factor was a greater deterrent than the fear of lamp igniting gas. This point was mentioned by a number of other speakers in the very interesting discussion which followed. Another speaker suggested that American methods of fixing lighting fittings to the coal cutters and conveyors might well be tried in this country; if the fittings could be moved as an integral part of the machinery this would save labour.

Newcastle Centre

At the November meeting of the Newcastle Centre, Mr. A. W. Jervis gave his paper on "Department Store Lighting." There were present at the meeting a number of visitors representing several of the large stores to be found in this area.

Mr. Jervis illustrated his most interesting lecture, the text of which followed his paper at the 1948 summer meeting, by a number of demonstrations with a large amount of equipment which had been assembled especially for that purpose.

Mr. Davison, a representative of a large departmental store, opened the discussion and, mentioning that his employers were building a new block of property, said that he would value the speaker's advice on the installation of cold cathode or hot cathode lighting. He also asked for suggestions as to the lighting of a basement which had no natural light. Mr. Rankin referred to the louvred fittings mentioned in the talk, and asked to be informed of the coverage normally to be expected from such a fitting and of the effect that would be obtained when used in a deep window. Mr. Rankin also referred to the subject of false ceilings, and inquired if the speaker inferred that all high ceilings should be so treated. Many other points were raised by different speakers.

In replying to the discussion, Mr. Jervis stated that in his opinion hot cathode lamps were the most efficient and suitable for departmental store lighting. He agreed that cold cathode lighting could be very good indeed when hidden in cornices, and mentioned the good effects of tailor-made installations when the tubes were moulded to the architectural features of the room. In general, however, he felt that the hot cathode lamps could be more suitably screened by reflectors. He deprecated the tendency for some users to install bare fluorescent lamps as glare often results, particularly where big installations provide long vistas.

In the lighting of basements the speaker suggested that the level of illumination might be lower than on other floors, but that in such situations the ceilings were usually lower, and fittings should be chosen which had a high upward light ratio.

Referring to shop window lighting, Mr. Jervis considered that 5 ft. 6 ins. was the maximum depth for well designed louvred fittings, and that in windows having a greater depth than this a second line of louvred fittings should be installed.

With regard to false ceilings, he did not advocate that all high ceilings should be so treated, as each lighting installation should be designed to tone in with the distinctive atmosphere of the department and harmonise with the physical features of the interior.

Huddersfield Group

The second meeting of the Huddersfield Group took place on Friday, November 4, 1949, when Mr. J. W. Howell addressed the members on the "I.E.S. Code in Relation to Textile Lighting."

Mr. Howell first gave a comprehensive review of the various processes in the textile trade (cotton, woollen, and silk), and showed that these processes needed different lighting techniques. Some processes needed more illumination because the visual task was much more exacting.

The lecturer then described the tests which had been made over long periods to ascertain the most suitable level of illuminations for

the different trades. He said that collaboration with managements and operatives had been sought and freely given after certain prejudices had been overcome. It was shown that good lighting, providing better seeing conditions, was an economic proposition both to the managements and operatives, besides providing more pleasant working conditions. It was, however, shown that there was an optimum figure above which there was no advantage to be gained; indeed above which some disadvantages were apparent. In general, lighting in textile factories still needed to be improved although vast improvements had been made during the last few years.

Forthcoming I.E.S. Meetings

LONDON

December 13th
Sessional Meeting. Messrs. W. A. R. Stoyle and G. D. Jones-Thomas on "The Operation and Maintenance of Fluorescent Lamp Installations." (At the Lighting Service Bureau, 2, Savoy Hill, London, W.C.2.) 6 p.m.

January 10th
Sessional Meeting. Messrs. R. G. Hopkinson and P. Petherbridge on "Discomfort Glare in Relation to the Lighting of Buildings." (At the Lighting Service Bureau, 2, Savoy Hill, London, W.C.2.) 6 p.m.

January 25th
Informal Meeting. "Lighting in Other Countries." (At the Lighting Service Bureau, 2, Savoy Hill, London, W.C.2.) 6 p.m.

CENTRES AND GROUPS

December 1st
Mr. C. H. Edlin on "Light as an Aid to Crime Detection." (At the South Wales Electricity Board Demonstration Theatre, The Hayes, Cardiff.) 5.45 p.m.

December 1st
Mr. F. G. Copland on "Analysis of Lighting Problems in an Industrial Undertaking." (At the Agricultural House, Queen Street, Exeter.) 7 p.m.

December 2nd
Mr. F. G. Copland on "Analysis of Lighting Problems in an Industrial Undertaking." (At the Grand Hotel, Bristol.) 7 p.m.

December 2nd
Mr. H. B. Mellor on "The Lighting of Road Transport Vehicles by Fluorescent Lamps." (At the Electricity Showrooms, Market Street, Huddersfield.) 7.15 p.m.

December 5th
Mr. P. L. Ross on "Fluorescent Lighting in Mines." (At the National Coal Board's Training Centre, Shalesmoor, Sheffield.) 6 p.m.

December 6th
Mr. G. W. Galley on "Theory Into Practice." (At the Lecture Theatre, Merseyside and North Wales Electricity Board's Showroom, Whitechapel, Liverpool, 1.) 6 p.m.

December 7th
Mr. W. A. R. Stoyle on "Operations and Maintenance of Fluorescent Lamp Installations." (At the Minor Durant Hall, Oxford Street, Newcastle-on-Tyne.) 6.15 p.m.

December 8th
Mr. P. Corry on "Lighting Aids to the Visual Art of Stage Production." (Joint Meeting with the British Drama League.) (At the Reynolds Hall, Manchester College of Technology, Sackville Street, Manchester.) 6 p.m.

December 9th
Mr. E. A. Langsdon on "Cold Cathode Lighting Equipment." (At the Imperial Hotel, Temple Street, Birmingham.) 6 p.m.

December 12th
Mr. J. T. Bowen on "Life within a Lighthouse." (At the Lighting Service Bureau, 24, Aire Street, Leeds, 1.) 6 p.m.

December 15th
Mr. R. Freestone on "Lamps, Old and New." (At the Yorkshire Electricity Board, 45/53, Sunbridge Road, Bradford.) 7.30 p.m.

December 15th
Mr. C. Higgins on "Neon Lighting." (At the East Midlands Gas Board Demonstration Theatre, Parliament Street, Nottingham.) 5.30 p.m.

December 20th
Mr. H. H. Bell on "Influence of Artificial Lighting on Industrial Health." (At the Institution of Engineers and Ship-builders in Scotland, 39, Elmbank Crescent, Glasgow, C.2.) 7 p.m.

December 21st
Mr. C. J. King on "Colour in Lighting." (Joint Meeting with the Royal Scottish Society of Arts.) (At the Welfare Club Hall of the City of Edinburgh Lighting and Cleansing Dept., High Street, Edinburgh.) 7 p.m.

December 21st
Mr. N. Hunter on "Some Films of General Interest." (At the Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough.) 6.15 p.m.

January 4th
Mr. L. C. Rettig on "Church Lighting." (At the Minor Durant Hall, Oxford Street, Newcastle-on-Tyne.) 6.15 p.m.

January 5th
Mr. L. C. Rettig on "Church Lighting." (At the Agricultural House, Queen Street, Exeter.) 7 p.m.

January 6th
Mr. L. C. Rettig on "Church Lighting." (At the South Western Electricity Board Showrooms, Bath.) 7 p.m.

January 6th
Annual Dinner. (At the Imperial Hotel, Temple Street, Birmingham.) 6 p.m.

January 6th
Mr. E. A. Langsdon on "Cold Cathode Lighting." (At the Electricity Showrooms, Market Street, Huddersfield.) 7.15 p.m.

January 8th
Annual Dinner. (At the Minor Durant Hall, Oxford Street, Newcastle-on-Tyne.) 6.15 p.m.

January 9th
Mr. H. W. Cumming on "Rare Gas Lamps—the Gas Arc." (At The Lighting Service Bureau, 24, Aire Street, Leeds, 1.) 6 p.m.

January 11th
Presidential Address by J. N. Aldington. (At the South Wales Electricity Board Demonstration Theatre, The Hayes, Cardiff.) 5.45 p.m.

January 12th
F. Jamieson on "Display Lighting." (At the Demonstration Theatre, East Midlands Electricity Board, Leicester Sub-Area, Charles Street, Leicester.) 6.30 p.m.

January 12th
F. G. Copland on "Analysis of Lighting Problems in an Industrial Undertaking." (Joint Meeting with the Electrical Contractors Association, Manchester Area Branch.) (At the Reynolds Hall of the Manchester College of Technology, Sackville Street, Manchester.) 6 p.m.

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The EDITOR Replies

It has often been said that "the eye" is the final arbiter of the merits of any example of lighting. But the judgment of "the eye" depends not only on present experiences but also on immediately and remotely previous experience, and the ideas elaborated from it. We are reminded of this by a note in a daily paper concerning the electric lighting of an ancient church in Hampshire. The new lighting of the interior, as well as floodlighting of the exterior, was first used on the occasion of the patronal festival on November 1. Unfortunately, before the service was due to take place, an interruption of the local electricity supply plunged the church into darkness. The resourceful vicar produced about a hundred candles, with which he lit the interior, and, in the words of the Press report, "the *mellow, softening glow* of the candles lit up the bold arches and ancient pillars. Then, as the service was about to begin, power was restored, and the *hard, cold, electric glare* outshone the candles." The italics are ours, and we strongly suspect the judgments pronounced upon the respective lightings were biased by the notion of ancient illuminants for ancient buildings. Certainly electric lighting is not intrinsically "hard," "cold," and glaring, and when properly designed for churches can beautify them more effectively than the time-honoured candle, and no less effectively arouse the sentiments of awe, wonder, and reverence.

Turning from sacred to secular buildings, another Press report draws attention to an important effect of cheerful colouring in factories. In a Sheffield engineering shop the dingy machines were repainted a light green and the walls were painted cream. As a result of appreciative comments by some of the men in the "locals," the firm no longer has a labour shortage, but a waiting list of 60 would-be employees. We know of other firms who have successfully attracted labour in this way, as well as by improving the lighting of their factories. One of these was recently "on the air" when the B.B.C. mobile recording unit enabled some of the workers to broadcast their impressions of the factory.

Elsewhere in this issue we print a letter relating to the use of the expression, "lighting units." The point raised by our correspondent deserves serious consideration, and we would be interested to know the views of other readers. If it is desirable to adopt another term to denote what is now referred to as a "lighting unit" in the I.E.S. Code, we recall that the word "illuminator" was used by a pioneer photometrist. But why not just "luminator" or "lumenator"?

PUBLICATIONS RECEIVED

"People and Paint"—the housewife's viewpoint on paints and finishes, reported and analysed by Mass Observations, Ltd., for the Paints Division of Imperial Chemical Industries, Ltd.

"Farm Lighting," by The Benjamin Electric, Ltd.

"Sight, Light and Efficiency," by H. C. Weston, Messrs. H. K. Lewis and Co., Ltd.

COLOUR GROUP

The forty-ninth science meeting of the Physical Society's Colour Group is to be held at 3.30 p.m., on Wednesday, December 7, 1949, at the Lighting Service Bureau, 2, Savoy Hill, W.C.2. A paper entitled "Camouflage" will be read by Dr. H. B. Cott, of the University Museum of Zoology, Cambridge.

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